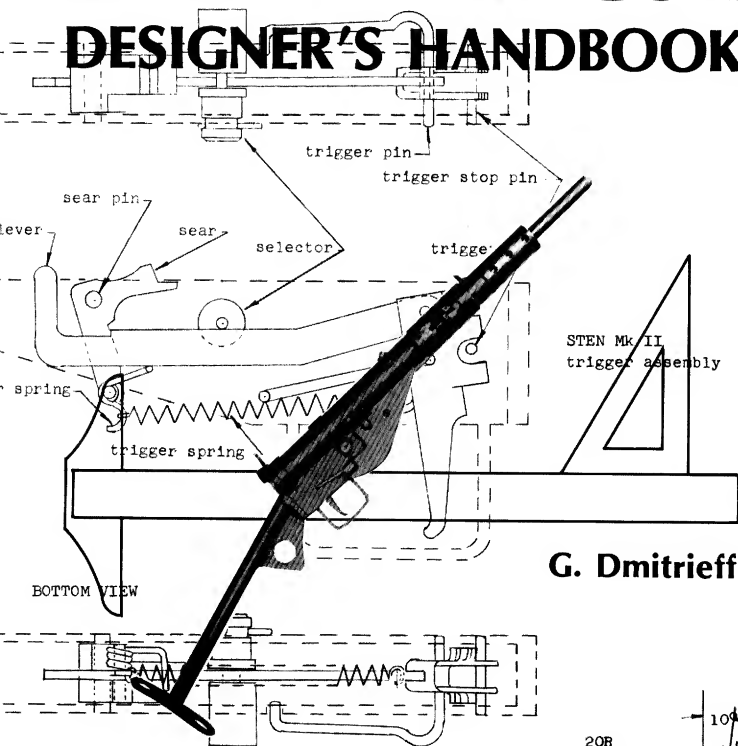


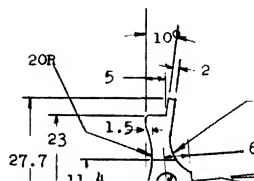
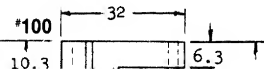
full automatic
position

TOP VIEW

SUBMACHINE GUN DESIGNER'S HANDBOOK



G. Dmitrieff



Submachine Gun Designer's Handbook

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Introduction

Submachine guns have been the subject of many books, some not so good. Most of these books contain detailed descriptions of various models plus an abundance of photographs.

The submachine gun, although a relative newcomer to the firearms arsenal, has captivated the public interest as the favorite arm of the G-men and the Chicago gangsters. World War II films made the "Burp Gun" and the "Grease Gun" household words.

The present work is intended not as an encyclopedia of various models, but rather as an introduction for the serious student of this type of weapon.

The historical and anecdotal aspects of the subject are kept to the minimum. The questions of the basic parameters of the design, manufacturing and product requirements are described in more detail.

To compensate for the lack of color photos and illustrations, this book contains complete engineering drawings of several models of well known submachine guns and the ammunition they use.

It is hoped that the present book will stimulate future arms designers in their challenging and interesting work.



SECTION I.

Submachine Gun History & Design Characteristics



Future Trends

The current weapon development and the organization and tactics of the ground troops will stimulate the development of a new generation of submachine guns.

In the present day (1980's) army the number of armored combat vehicles such as tanks, self-propelled artillery, armored personnel carriers, self-propelled AA and AT weapons, etc., increased to unprecedented numbers. Furthermore, the number of crew-served weapons and special equipment, such as mortars, heavy machine guns, rocket launchers, grenade launchers, surveillance radars, communications equipment, computer units, etc., in basic infantry units increased to the point where the number of individual riflemen, whose primary function is rifle fire, is severely reduced.

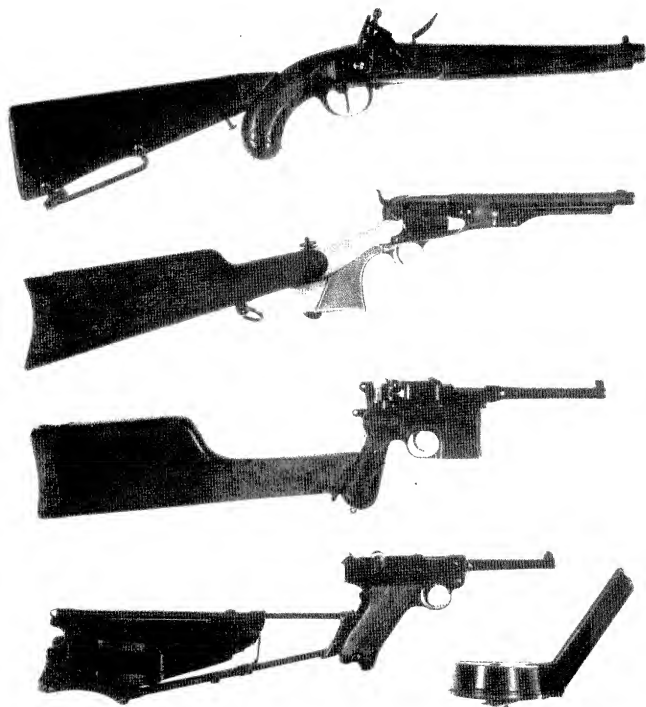
The personnel in combat vehicles and those attached to crew-served weapons require only a personal weapon suitable for close combat against enemy personnel. This trend is evidently demonstrated in the proliferation of light rifles with folding stocks and short barrelled models, telescoped construction types, etc. These rifles are chambered for medium powered cartridges. To make a virtue of necessity, the standard rifles and

light machine guns are also chambered for this round.

A more logical and functional approach would be to consider the machine gun, both light and medium, and the sniper rifle as special weapons in the same class as grenade launchers and/or rocket launchers, and to retain the classic full power cartridge. The individual weapon required for close defense of personnel should be a light (4-5 lbs.), compact submachine gun with suitable muzzle brake to allow controlled offhand automatic fire. The round will deliver 1200-1500 ft. lbs. of muzzle energy, with an effective range of 150 meters.

The existing 9x19 (9mm Parabellum), 7.62x25 (7.63 Mauser) and the .30 M1 carbine cartridges with improved ballistics would satisfy these requirements.

A new submachine gun of this type would make maximum use of aluminum castings and/or extrusions, plastic materials, stamped components, etc., without additional machining. A simple blowback system and expendable plastic magazine with feed lips integral in the weapon receiver would assure reliable operation at minimum cost.



Prior to the development of the submachine gun, numerous pistols were fitted with detachable buttstocks in an attempt to provide a weapon with the effectiveness of a rifle or carbine and the convenience of a pistol. From top to bottom, also illustrating several steps in the evolution of pistols in general, are a German flintlock, Colt 1860 Army revolver, Mauser Model 1898 and the P'08 Luger.



Historical Notes

The need for a light and compact arm, more accurate than an ordinary pistol has been felt by soldiers since the introduction of firearms. The first step in this direction was the carbine. A carbine, as understood originally, was a shortened musket, or rifle, firing the same cartridge as the standard primary weapon and lighter only by the weight of the barrel and stock, which were cut off. This solution was not satisfactory because the weight and size reduction of the rifle were not sufficient to meet the desired objectives.

Another approach to the problem was a pistol with a detachable buttstock. A pistol, or revolver in the hands of the average man is a relatively ineffective weapon, due to the short sighting radius, the heavy recoil and the unsteady base offered by the one hand hold. Consistently hitting a stationary 12 inch target at 100, or even 50 yards, with a military pistol or revolver is possible only by experienced shooters. One of the first buttstock equipped pistols was a German flintlock (see photo). Such a pistol, fired with buttstock attached, was practically the equal in accuracy to the Brown Bess musket at 100 yards. This approach was quite successful and was adopted for the Colt 1860 Army revolver and the famous Mauser Model 1898 pistol and the even more famous Luger. The buttstock equipped pistol is perpetuated today by the Soviet Stechkin pistol.

The present day submachine gun was born during World War I, when it was found that automatic pistols could not be controlled during full automatic fire. In the subsequent development of the submachine gun, two other changes were

incorporated: simplification of the mechanism and a larger magazine for adequate ammunition supply. The first submachine gun designed along these lines was the Villar Perosa, which was discarded after a short time because of its extremely high cyclic rate. The first successful blowback model, incorporating practically all characteristics of today's submachine guns, was the Bergman "Muskete", chambered for the 9mm Parabellum cartridge. The efficiency and lethality of this type of weapon were later confirmed throughout the world by the Thompson submachine guns Models of 1921, 1927 and 1928. The need for such weapons in close combat and under conditions of limited visibility, such as fog, night, woods, etc., has been recognized by all major governments. The submachine gun was widely used in the Spanish Civil War and the Gran Chaco conflict, but it was in the Russo-Finnish War that the Suomi model established the reputation of submachine guns as qualified members of the military family. The hard learned lesson was not forgotten by the Red Army with the advent of World War II. During the course of the war, the number of submachine guns in the Soviet units increased until 55 percent of all hand held weapons in infantry companies were of this type. The Germans followed suit and their reports indicate that in the northern sectors of the Eastern Front, practically all rifles issued to the infantry were replaced by the Schmeisser MP40. The British necessity for a submachine gun resulted in the development of the excellent Sten, which is a classic example of a simple, reliable and low cost mass produced weapon. The ultimate in

simplicity and ease of manufacture in the submachine gun field remains the US M3A1 "Grease Gun". Although designed and used during World War II it is still the best weapon of its type when considered from the production point of view. Further development of submachine guns was continued after the last war, as evidenced by the Danish Madsen MP-45, the Swedish "Karl Gustav" and the latest Israeli Uzi model.

The brief history of submachine gun development would not be complete without mention of the locked breech types. When the U.S. Army adopted the semi-automatic M-1 carbine, the fully automatic version was the next logical step. The German Army in turn introduced the MP43/44 *Sturmgewehr*, or "assault rifle". Since both the

M-2 carbine and the *Sturmgewehr* use ammunition which is at least twice as powerful as the .45 ACP or 9mm Parabellum cartridges, it was considered necessary to use a locked breech rather than the plain blowback system. Because of this method of locking and the more powerful ammunition used, it is sometimes assumed that a new class of infantry weapon was introduced. However, upon closer look, it will be seen that these guns are only one step further in the evolution of the submachine gun. As the early Thompson models used the Blish block because the plain blowback was considered inadequate, so the M-2 carbine uses a rotary bolt to keep the breech closed. Actually it is entirely feasible to design a six pound submachine gun using the blowback system to fire the carbine cartridge.



Basic Requirements

The number of would-be designers of submachine guns would easily provide personnel for several infantry divisions.

Anybody only slightly familiar with firearms usually considers himself an expert in this respect. In reality, the design and production of a good submachine gun requires the same kind of sound engineering as any other mass produced item, be it an electric fan, 10 speed bicycle or a household appliance.

Unfortunately, the controlling parameters of a new submachine gun are rarely dictated by the end user and the designer alone. The purchaser is the key decision maker. Thus the factors which must be considered are (not necessarily in the order of importance):

1. *Type of User.* This item has quite often been neglected in the past, even though its importance is obvious. The users may be divided into the following groups:
 - a. Armed forces personnel as a whole — comprising members of all branches of the service, having the minimum required training and skill to operate the issue weapon.
 - b. Special forces — these are selected, highly motivated and trained professionals with superior training and skill in the weapon's use; hence the weapon may be more complex in the assembly, disassembly and use.
 - c. General population — this group encompasses the defense para-military forces,

partisans, men, women and children who may be required to use the weapon. Extra safety features, reduction of recoil and pleasing appearance must be emphasized.

2. *Annual Weapon Quantity Required.* This factor determines the degree of attention given to the detail design, the choice of available materials and manufacturing methods. The skill of the manufacturing labor force must also be considered.
3. *Availability of Local Sources of Materials* and their non-strategic nature — an essential element of any weapon design. However, for submachine guns which form the backbone of partisan and self-defense forces this design factor requires extra emphasis. Regardless of how excellent the weapon may be, if it cannot be made in an emergency situation, it is worthless.
4. *The Available Manufacturing Technology and the Equipment* suitable for submachine gun production varies from location to location. A weapon using investment casting, powdered metal and complex stamping parts may be acceptable to a highly industrialized area. Such design will not be acceptable in a remote area where only small workshops are available. On the other hand a weapon using screw machine parts and components used in other products, such as tubing and piping, may be acceptable with some modifications by all manufacturers.

5. *Overall Weight* of a weapon is mainly a tactical rather than technical requirement. The control of fire, hit probability, and accuracy are more important in the design of a hand held weapon than the minimum weight possible. Most submachine guns designed in the past weighed 9-12 lbs. fully loaded, since this was the weight of a loaded service rifle with bayonet and other attachments. The introduction of lightweight rifles, such as the U.S. M-1 carbine, the M-16, etc., led to the acceptance of the lightweight submachine gun concept. Most submachine guns used in World War II could be built today from aluminum and/or magnesium alloys components without functional degradation and yet weigh about half as much as the old steel models.
6. *Overall Length* of a submachine gun was in the past controlled by tradition. Bayonet attachment, two-hand firing hold and the "must look like a rifle" mentality were the controlling criteria. The "through the grip" magazine and telescoped bolt-barrel were unacceptable to the decision makers. Today's generation — fed on science fiction rather than on John Wayne films — allows more freedom in the external form of the weapon.
7. *Accuracy* of a shoulder weapon is usually the most controversial factor, widely discussed, yet rarely defined. Quite often the actual accuracy of the weapon/ammunition system is confused with the hit probability which includes not only the weapon/ammo but also the shooter, the ambient conditions and the target. In the days when the rifle was the only weapon of the infantry, the accurate fire by individual riflemen was the decisive factor. Accurate range and wind estimation was an essential part of the training. Firing at ranges of 1000 yards was standard tactics. Platoon and company salvos were used in lieu of the then non-existent or unavailable machine gun bursts. With the saturation of infantry units with machine guns, mortars, grenade launchers, etc., the importance of accurate individual rifle fire has been greatly reduced. Today's rifles use simplified sights and are expected to be accurate up to 500 meters only. The accuracy of the submachine guns follows the same trend. Early models had sights with adjustment for windage and for

elevation for ranges of 500-600 yards. Post-World War II models have either a fixed sight or an L-type aperture sight for 100 and 200 meters' settings.

Popular belief based on movie experiences considers submachine guns "garden hoses" squirting a stream of bullets. Actually, most automatic fire consists of aimed short bursts of 3 to 5 rounds. The accuracy of a well made submachine gun fired semi-automatically or single shot is comparable to the acceptance specifications of some sporting and military rifles fired at 100 meters under the same conditions.

To obtain an indication of the accuracy expected from a submachine gun the following test was performed:

WEAPONS

Samples were selected at random from several guns available. Only one sample of each weapon model was used in the test. All samples were standard issue weapons, in used condition and good working order. The following models were tested:

Sten Mk II
PPSh 41
M3A1
Thompson M1

AMMUNITION

U.S. made commercial ammunition was used throughout the test.

RANGE

Indoors at 100 yards.

FIRING POSITION

"Muzzle and elbow" rest used for testing sporting rifles.

TYPE OF FIRE

Semi-automatic only; the M3A1 sample was fired by loading each round singly as this model does not have a semi-automatic trigger setting.

TARGETS

Five 5-shot groups.

SHOOTERS

One male rifleman, experienced, excellent shot. One male rifleman, familiar with firearms, average shot.

RESULTS

The overall averages of the above shooters were:

WEAPON	SPREAD in MM's		
	Vertical	Horizontal	Extreme
Sten Mk II	250	254	310
PPSh 41	328	250	400
M3A1	354	411	530
Thompson M1	274	267	363

The poor scores of the M3A1 were due mainly to the poor balance of the weapon and the relatively heavy bolt. The Uzi with its better than average sights and good trigger pull produced groups which were comparable to those of some sporting and military service rifles fired under the same conditions.

Although limited in scope, the above tests indicate that a submachine gun with good sights and adjustable trigger pull can readily satisfy the requirements of a standard military rifle at ranges of 100-150 meters. Beyond that range the large drop of the pistol ammunition makes the submachine gun impractical.

8. *Special Features.* The embellishment of a basic weapon with attachments of dubious value to make it into a universal tool has been here for centuries. Halberds combined with matchlock pistols, Civil War carbines with coffee mills in the buttstock and submachine guns with bayonets are typical examples. The functional and practical attachments on a submachine gun are:

- Muzzle brake, such as used on the PPS 42, which practically eliminates muzzle climb.
- Silencers — making the weapon most effective for special operations.
- Magazine charger — as in the VZ23 models.

9. *Ammunition.* Most submachine guns have been chambered for service pistol cartridges, i.e., 7.62x24mm, 9x19mm and .45 ACP. Some special and/or police models are made in .32 ACP while others have been chambered for the U.S. .30 M1 carbine cartridge. However, the 9x19mm and 7.62x24mm cartridges are suitable for extra heavy loading which, when fired in an 8 to 12" long barrel, produces ballistics in the

class of the U.S. .30 M1 carbine round. Since the 9x19mm has been standardized in NATO and the 7.62x24mm weapons are currently not issued to the first line units of the Warsaw Pact, it can be assumed that any new submachine gun design outside the Warsaw Pact will be chambered for the 9x19mm cartridge.

10. Last, but not least in importance is the *Subjective Opinion* of the selection committee. Such subjective feelings are covered up by rationalizations, selected statistical data and limited tests, and dubious historical facts. National pride, political and economic advantages, and personal ambitions are included in this factor.

Now follow the factors which are more technically specific:

11. *Operating System.* This term describes the method of cartridge energy utilization to perform the necessary operations of empty case ejection, cocking and reloading the weapon. The most common systems are gas operation (M1 rifle and M1 carbine), recoil operation (Browning machine guns, Colt Model 1911 pistol) and blowback (M3A1 submachine gun). Due to the low cartridge impulse and the strong case construction of the 9x19mm cartridge the simple blowback is the most commonly used operating system in submachine guns.
12. *Locking System.* This is the method of closing the breech end of the barrel during firing. The closure can be of three basic types:

- Positive — when the cartridge case is kept in the chamber by a rigid mechanical member such as a rotating bolt lug, tilting bolt, or displacement of a separate bolt lock.
- Semi-rigid — when the cartridge case motion is restrained during the high chamber pressure. The breech is not positively locked but must be forced back with a great mechanical disadvantage. Wedged rollers, steep pitch screw or gas assisted locks are typical examples.
- Inertia — the free motion of the case from the chamber is slowed by the large mass of the bolt. This locking

system is the most common type used in submachine guns.

13. *Cyclic Rate.* Submachine guns in current use have cyclic rates of fire varying from 150 to 1200 rounds per minute. Some authorities prefer slow rates for better control of the weapon and the potential of long sustained bursts. Advocates of high cyclic rates cite better hit probability of short bursts against targets of opportunity, etc. The optimum cyclic rate lies probably between these extremes, i.e., 600-700 rounds per minute.

14. *Magazine.* This is the most important single component of any repeating firearm. Its modest appearance belies the degree of effort expended on its design and manufacture. In submachine guns the drum magazines were preferred originally for their large capacity. The basic drum magazine with a spring driven follower as used in the Suomi and PPSH42 offers the maximum capacity with the minimum volume per round. However, the mechanical complexity, difficulty in reloading a partially empty drum, plus other handling inconveniences led to their gradual decline.

Box magazines are of 30 to 40 round capacity. The reduced capacity, as compared to the drum, is more than compensated by improved handling. Many varieties of drum and box magazines were tested in the past. Rotating, folding, multi-column, cut-off equipped, etc., were tried, but none passed the rigid test of field use and ease of manufacture. It is safe to predict that the staggered double column magazine will continue to be the preferred choice.

15. *Firing Mechanism.* Early submachine guns were provided with selective semi- and full automatic trigger systems. Some later models were also equipped with burst control limiting the number of rounds fired per each trigger pull. Special models were offered in semi-automatic only for training and/or police use. These refinements, while good in theory, were not so good in practice. The added complexity of burst control and the added cost were not justified. All modern models have returned to the original semi- and full auto trigger only.

Finally come the purely technical design features:

16. *Barrel Length.* Barrel lengths used on submachine guns fluctuate between 200mm for the Sten to 318mm for the Suomi. The great majority of models have a length of 250mm. This yields practically maximum muzzle velocity for the given cartridge yet makes the weapon compact.

17. *Bolt Weight.* With the exception of the H&K MP5, all modern submachine guns use a simple blowback locking system. In this case the bolt weight is primarily controlled by the minimum weight necessary for safe operation. Even weapons with fixed firing pins must be considered as firing from a closed bolt. A bolt with fixed firing pin has certain residual energy in forward direction when a normal round is fired. However, with a slow primer/powder ignition or a hang fire this energy is gone when the cartridge fires. In the old models the minimum recoiling weight was no less than 560 grams. However, limited tests performed with a Winchester Model 1907 rifle (using blowback locking) and a Thompson M1 submachine gun, both converted to fire the .30 M1 cartridge, demonstrated that a 570 gram bolt was adequate even for proof rounds. A 450 gram bolt was found sufficient for the standard round fired under normal operating conditions.

It is reasonable to assume that from the safety point of view a 500 gram bolt is sufficient for a 9x19mm or 7.62x24mm round.

18. *Closing Spring.* During the operating cycle the closing spring acts as an accumulator of energy. It converts the kinetic energy of the recoiling bolt into the potential energy necessary to push the bolt forward, to strip a new round from the magazine, to chamber and fire it. This spring energy must be large enough to overcome any minor feeding problems, to operate the bolt under increased friction due to mud, sand, snow or other ambient conditions, the shooter's position and weapon hold. Yet the spring energy must be low enough for comfortable cocking of the weapon. The earlier models used springs with 0.15 Kg-m energy, while the Sten and MP40 have springs of 0.80 Kg-m energy. The current models operate in the intermediate range of 55-60 Kg-m. The final choice of closing spring characteristics is related not only to positive

CHARACTERISTICS OF SIMPLE BLOWBACK MACHINE GUNS (Dimensions given are metric)

MODEL		Uzi	Vz23	M3A1	MP40	Sten Mk II	PPS43	PPSh41
FEATURE		UNITS						
Weight, empty	Kg	3.90	3.26	3.94	4.17	3.26	3.30	4.71
Weight, loaded	Kg	4.20	3.55	4.54	4.54	3.65	3.65	5.52
Magazine capacity		25/40	24/40	30	32	30	35	71
Cartridge type		9x19	9x19	.45	9x19	9x19	7.62x24	7.62x24
Length, open	cm	64.0	68.1	74.7	83.8	75.2	82.6	83.8
Length, closed	cm	NA	NA	56.5	63.5	NA	62.0	NA
Barrel length	cm	26.0	24.5	20.6	25.2	20.0	25.0	28.7
Bolt weight	gm	680	680	860	635	635	560	590
Bolt stroke	cm	11.0	10.0	15.5	15.0	13.5	14.5	8.5
Closing spring energy	Kg-cm	51.3	37.6	70.0	63.5	79.0	59.5	35.0
Cyclic rate	rds/min.	600	650	450	560	580	650	900
Closing spring								
wire diameter	mm	1.14	NA	0.81	1.22	1.70	1.00	0.90
spring OD	mm	8.5	6.6	9.4	12.7	25.4	8.5	6.9
number coils active		120	176	77	54	15	86	74
free length	cm	34.6	NA	37.6	33.0	24.0	30.0	20.0
initial length	cm	25.0	30.0	23.0	25.0	17.2	24.0	15.5
final length	cm	14.0	20.0	7.5	10.0	3.7	9.5	2.7
initial load	Kg	2.95	2.40	2.90	2.26	2.90	1.90	2.26
final load	Kg	6.35	5.2	3.35	6.41	8.80	6.45	6.25
spring rate	g/mm	31.0	26.8	19.6	27.7	44.0	32.2	50.0

CHARACTERISTICS OF SIMPLE BLOWBACK MACHINE GUNS
(Dimensions are U.S. Standard)

MODEL		Uzi	Vz23	M3A1	MP40	Sten Mk II	PPS43	PPSh41
FEATURE		UNITS						
Weight, empty	Lbs	8.6	7.2	8.7	9.2	7.2	7.3	10.4
Weight, loaded	Lbs	9.2	7.8	10.0	10.0	8.0	8.0	12.1
Magazine capacity		25/40	24/40	30	32	30	35	71
Cartridge type		9x19	9x19	.45	9x19	9x19	7.62x24	7.62x24
Length, open	In.	25.2	26.8	29.4	33.0	29.6	32.5	33.0
Length, closed	In.	NA	NA	22.2	25.0	NA	24.5	NA
Barrel length	In.	10.2	11.2	8.1	9.9	7.8	9.8	11.3
Bolt weight	Lbs.	1.5	1.5	1.9	1.4	1.4	1.24	1.3
Bolt stroke	In.	4.4	3.94	6.1	5.8	5.3	5.6	3.2
Closing spring energy	In.-Lbs.	44.6	32.7	2x30.4	55.0	68.6	51.8	30.5
Cyclic rate	rds/min.	600	650	450	560	580	650	900
Closing spring								
wire diameter	In.	.045	NA	.032	.048	.067	.040	.036
spring OD	In.	.34	.26	.37	.50	1.00	.34	.27
number coils active		120	176	77	54	15	86	74
free length	In.	13.6	NA	14.8	13.0	9.4	11.6	7.9
initial length	In.	9.9	11.8	9.0	9.8	6.8	9.3	6.0
final length	In.	5.5	7.7	2.9	4.0	1.5	3.7	2.7
initial load	Lbs.	6.5	5.3	6.4	5.0	6.4	4.2	5.0
final load	Lbs.	14.2	11.2	13.2	14.0	19.4	14.2	13.8
spring rate	Lbs./Ins.	1.75	1.5	1.1	1.5	2.5	1.8	2.8

functioning but also to the bolt stroke, desired cyclic rate and the shooter's comfort.

19. *Bolt Stroke.* Bolt stroke is the distance which the bolt travels in the receiver, from its forward, closed position, to the maximum rearward displacement possible. While it is desirable to keep the bolt stroke as short as possible in order to make the weapon receiver short and compact, there are several factors which affect this dimension.

In spite of the apparent importance, the bolt stroke is actually a minor factor in the design. The longest and the shortest bolt strokes of many weapons measured are 155mm on the M3A1 and 63mm on the Beretta 38/42. Yet the overall length of these weapons is 747mm and 787mm respectively.

The theoretical minimum bolt stroke is the distance from the rear end of the magazine to the breech end of the barrel. However, the staggered box column magazines do not allow a perfect alignment of

the top round with the barrel bore. Hence the top cartridge actually moves at an angle to the bore axis and requires additional distance before lining up with the chamber. Another important factor of the bolt stroke length is the choice of buffered vs. free rear impact.

Given an unlimited travel, the bolt would continue rearward, compressing the closing spring until the bolt energy became converted into the potential energy of the spring and the bolt stopped. Such action gives the softest shoulder recoil but requires a long bolt stroke.

Another solution allows the bolt to travel only a fixed distance, compressing the closing spring and impacting on the rear end of the weapon receiver. To reduce the severity of this impact requires a buffer.

In actual operation the bolt kinetic energy is not uniform. Depending on the ambient temperature, cartridge loading, friction, shooter's stance and grip plus several other elements, this available energy varies considerably from shot to shot.



Design

After careful consideration of all the factors presented in the preceding chapter, the designer tries to select the parameters which will satisfy the majority of users and which will produce a weapon better than those it replaces.

Following is a hypothetical case of such design selection. Let's assume that the desired submachine gun should:

1. Be useable by para-military defense forces comprising women and adolescents.
2. Be as light and compact as possible.
3. Have a selective semi- and full automatic fire mode.
4. Be chambered for the 9x19mm Parabellum cartridge.
5. Have a maximum effective range of 150 meters.
6. Use simple blowback action for locking and operating system.
7. Be produced on equipment and with skills available in an automotive repair shop.

With the above objectives clearly in mind the design will further develop into more details:

1. Since the weapon will be used by semi-trained personnel, the assembly, disassembly and field stripping must be very simple without the use of tools. The pistol grip size and the stock dimensions must be proportioned for a small, light boned individual. The weapon loading, cocking and firing must be accomplishable by both left- and

right-handed individuals. Hence the magazine release latch and the trigger safety should be operable by the trigger finger hand (left or right) while the magazine and bolt cocking unit are reached by the other hand. The L2A3 weapon with the magazine located horizontally on the left of the receiver is notoriously deficient in this respect. Furthermore, the bolt cocking unit should not reciprocate during firing so that the shooter can hold the weapon comfortably and safely without fear of injury by the cocking handle. Aside from the trigger safety, there must be a positive mechanical safety which blocks the bolt motion in the SAFE position. The M3A1 trap door safety and the finger slot in the bolt instead of a cocking handle is so far the best solution to this requirement.

The use of plastics and aluminum alloys wherever possible would reduce the need for periodic cleaning and lubricating of the weapon.

2. The light weight and compactness are easy to achieve. A "through the grip" magazine, bolt wrapped around the barrel and a folding stock allow for a weapon construction which is only slightly larger than a military pistol.

In actual use, and particularly during carrying, the weight of the weapon is more objectionable than its size. It is more comfortable to carry a light, flat, even slightly longer weapon than a short but bulky and

heavy one. This applies whether the weapon is carried exposed or concealed. Control of muzzle jump during automatic fire is easily achieved by a simple spoon-like muzzle suppressor.

3. The selective semi- and full automatic mode of fire may be accomplished by a variety of means. Examples of these methods are the Uzi, Sten and PPSH working drawings included in this chapter. Although the Uzi is the most "elegant" in design and execution, the others have certain manufacturing merits which may be considered. As in other projects with sound engineering, it pays to study in detail what has been accomplished by others to avoid "reinventing the wheel". Copying a good and proven design has been a mark of all successful weapons. The AK-47 assault rifle, probably the most reliable in service today, uses the trigger system which was designed by John Browning and later used on the M1 Garand rifle. In turn the Galil rifle is a copy of the AK-47 but rechambered for the 5.56x45mm cartridge.

Although a full automatic fire trigger system is the acme of simplicity such a weapon requires more training and fire discipline than the personnel in item 1 above is expected to have. The semi-automatic feature on a submachine gun is most useful in basic training, target practice, sniping at short range, etc. The increase in mechanical complexity is fully justified in this case.

4. The 9x19mm Parabellum cartridge selected for this study is being used by more models of submachine guns than any other. This universal popularity of the Parabellum round is due to its relatively good external ballistics, excellent cartridge construction and reasonably simple manufacturing process.

The 7.62mm Mauser cartridge, although superior in external ballistics, has a case which is more complex than the 9x19mm. The .45 ACP, on the other hand, is superior to the Parabellum only in relative stopping power.

The drawing and specifications on each cartridge type are given in the section on ammunition. These values are indicative of the average commercial ammunition only. The military loads fired in submachine guns

with 250-300mm barrels give muzzle velocities of 415m/sec. and 490m/sec. for the 9x19mm and the 7.62x24mm cartridges respectively.

It is safe to assume that the 9x19mm cartridge will remain the standard submachine gun round for years to come. The conventional ogive ball bullet will be modified for improved stopping effect. The brass jacket/lead core construction will be replaced by a copper plated mild steel bullet.

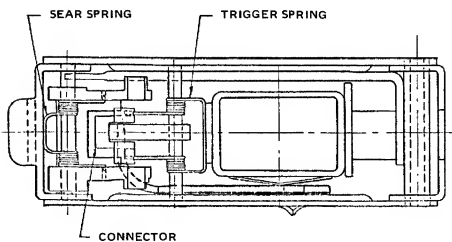
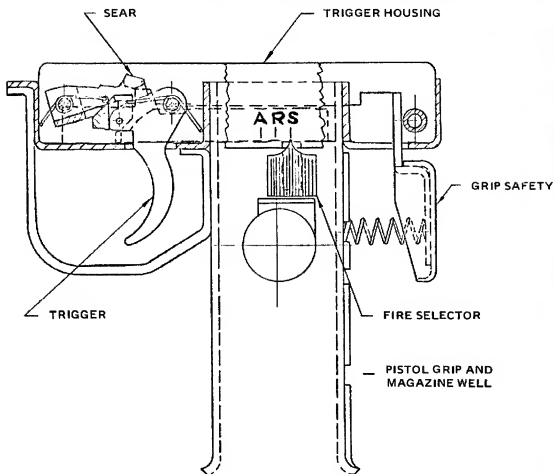
The 70/30 brass case will become a copper clad steel case. These modifications will be introduced to reduce material cost only, not to change the cartridge performance.

5. The maximum effective range of 150 meters is determined not only by the cartridge/weapon system, but by the expected target size as well. The cartridge ballistics combined with the short sighting radius, relatively heavy trigger pull and firing from an open bolt are not comparable to target rifle performance. However, there are other factors affecting the ability to hit the target besides these. The major hit probability factors affecting the combat effectiveness are listed below.

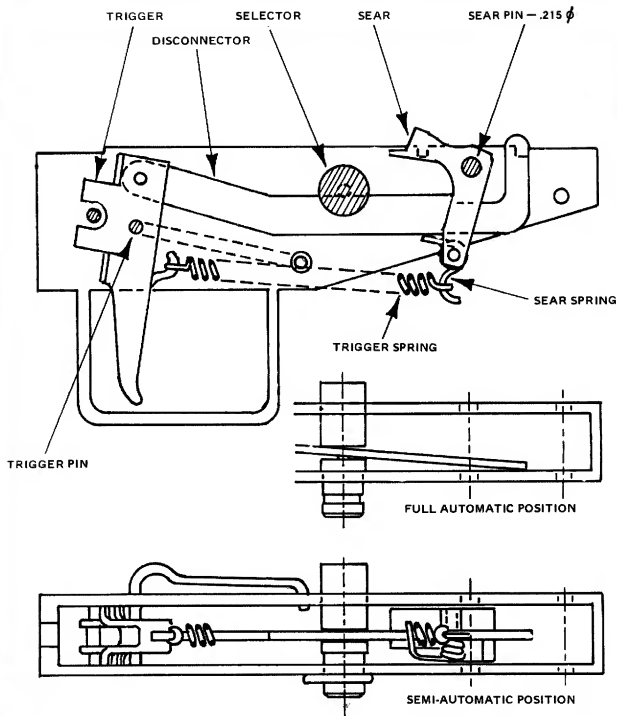
HIT PROBABILITY FACTORS

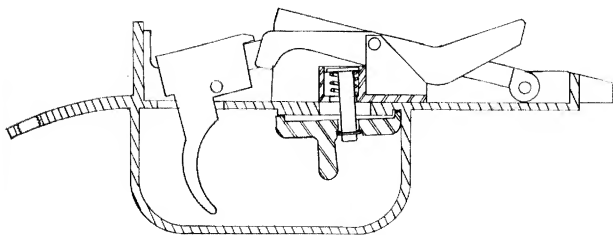
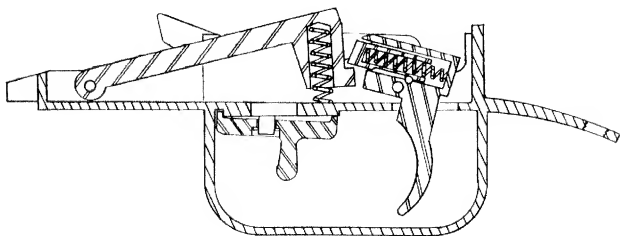
1. Basic accuracy of weapon/ammo system.
2. Shooter's inherent skill.
3. Shooter's position.
4. Aiming error: sight alignment, range estimation, wind estimation.
5. Target: size, sharpness (color contrast), exposure duration, movement.
6. Ambient: reduced visibility (fog, night, sun glare), rain or snow, temperature.
7. Psychological stress: fear, exposure to enemy fire.

Full size drawings for man-sized targets at 150 meters extrapolated to 50 feet and at 200 meters extrapolated to 25 meters appear on pages 21 and 22.

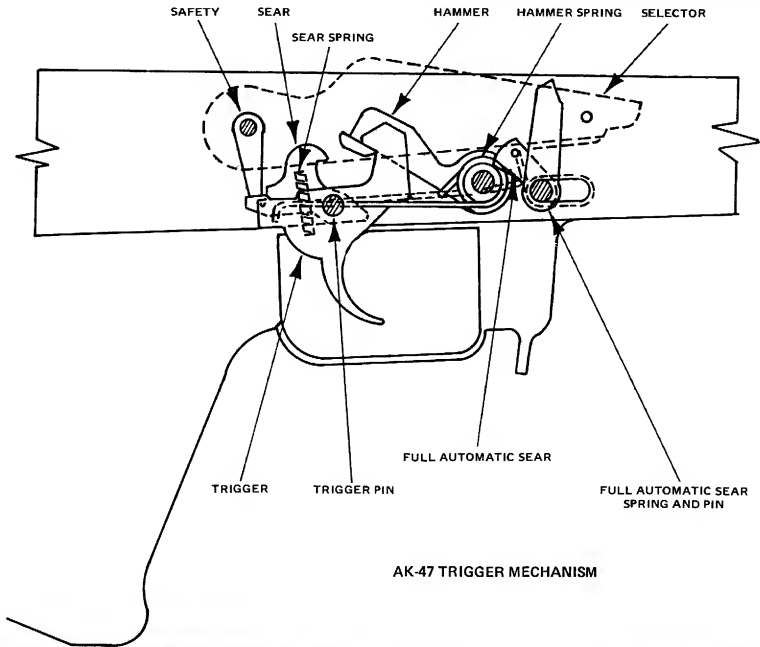


UZI TRIGGER MECHANISM

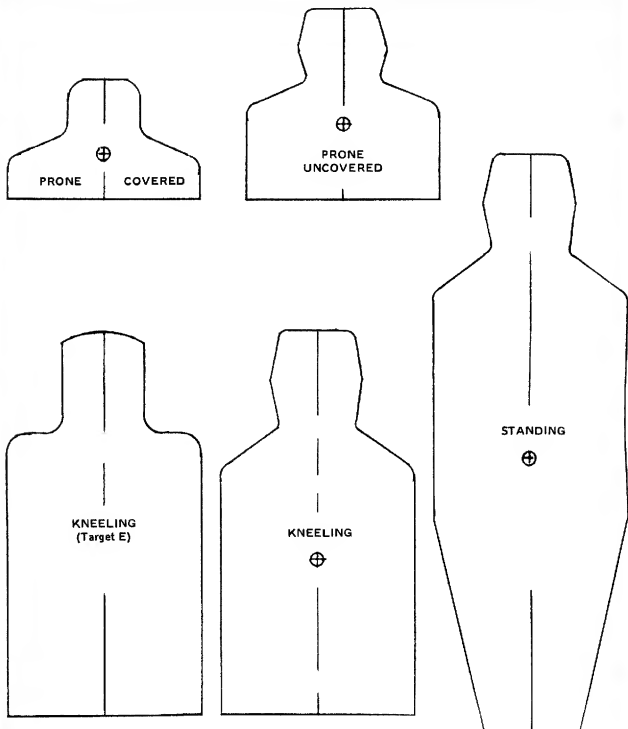




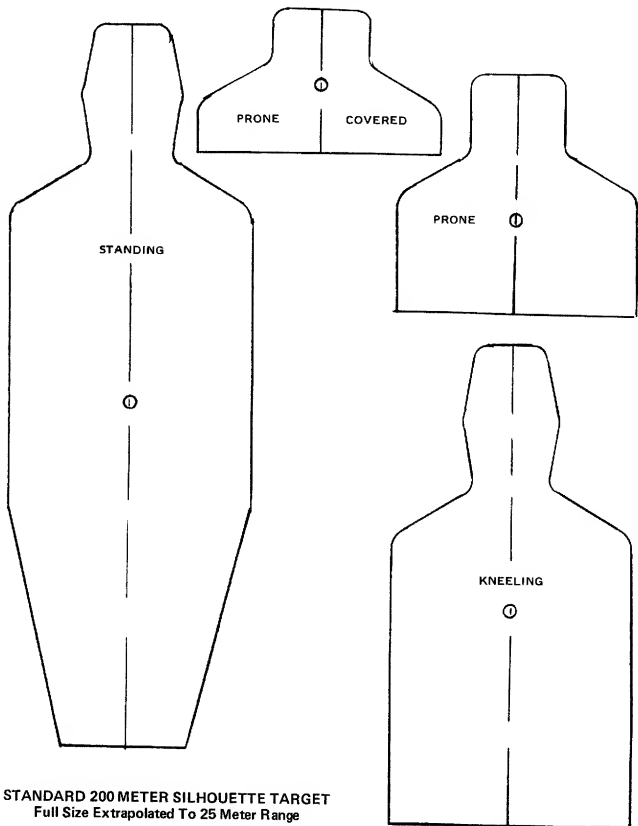
PPSh 41 TRIGGER MECHANISM



AK-47 TRIGGER MECHANISM



STANDARD 150 METER FULL SIZE SILHOUETTE TARGET
 Extrapolated To 50 Ft. Indoor Range



STANDARD 200 METER SILHOUETTE TARGET
Full Size Extrapolated To 25 Meter Range

6. A simple blowback locking and operating system is the most elementary breech loading method in existence. Its simplicity, reliability and low cost make it optimum for use in submachine gun design. As the name implies, blowback operation depends on the rearward motion of the spent case under the gas pressure in the barrel. The bolt inertia performs the locking. As a direct application of Newton's Third Law, the necessary bolt mass is determined by the mass and velocity of the bullet and the powder gases. The bolt displacement during the high bore pressure must be small to prevent separation of the case head from the case body. The plain blowback is poorly suited for weapons chambered for high impulse rifle cartridges without special precautions such as pre-ignition, lubricated ammunition, fluted chambers or extra-heavy case construction. However, using straight taper cases, such as a pistol or carbine cartridge, this system is the preferred one.

The dynamic system analysis of simple blowback has been the subject of numerous studies and is amply described in the literature. Some of the recent studies are detailed in *The Machine Gun, Vol. IV*, by G. Chinn, *Elements of Armament Engineering, part III, Weapon Systems and Components*, AMCP 706-108 and *Engineering Design Handbook, Gun Series, Automatic Weapons*, AMCP 706-620.

However, the above studies evaluate all aspects of the system in depth mainly because they are concerned with machine guns and automatic cannons.

In submachine gun analysis such complex calculations and evaluations of various factors may be neglected as irrelevant. The calculations of blowback submachine gun cycle are of the simplest, yet completely adequate form. In practice they are performed only to verify the preselected design parameters, prior to the start of the actual drawing work.

An example of such a computation may be seen on the following page.

It is obvious from the results presented in the design parameters that:

1. Lightening the bolt increases the cyclic rate.

2. Shortening the bolt travel increases the cyclic rate.
3. Although the bolt momentum remains the same (for the same cartridge) a lighter bolt traveling faster will have higher energy than a heavy bolt moving slowly because the energy is a function of the square of the velocity.
4. A light bolt and short stroke require a stiff spring to absorb the energy.
5. Since the shooter must operate the weapon manually for the first shot, the "stiffness" of the closing spring is the key controlling parameter of the blowback design.
6. Introduction of a second closing spring which acts as a buffer will alleviate the above restrictions but introduces in turn more complex construction, and more components and has therefore not been favored in the past.
7. The cyclic rate formula used herein gives values which are actually slightly lower than those measured on firing models. But because of its simplicity it is preferred to the formulae given by other authors. Furthermore, the formulae given by Chinn (see above) are more complex and the values are higher than actual cyclic rates measured.

Now let's also check the movement of the spent case during the time when the bullet travels down the bore. This time is approximated by the equation

$$t = \frac{\text{barrel length}}{2/3 \text{ muzzle velocity}} = \frac{0.250 \text{ m}}{2/3 \times 400 \text{ m/sec.}} = 0.0009 \text{ sec}$$

during this time the spent case moves a distance equal to

$$d = 2/3 (\text{max. bolt velocity}) \times \text{barrel time, or} \\ = 2/3 \times 600 \text{ cm/sec} \times 0.0009 \text{ sec.} = 0.36 \text{ cm} = 3.6 \text{ mm}$$

If one cuts open a spent Parabellum case along the longitudinal axis the robust construction of the case head is apparent. The thickness from the case head face to the inside bottom of the case is about 3.5 to 3.8mm. Thus the importance of a strong case is obvious.

After the bullet leaves the muzzle the jet of powder gases continues to stream out of the muzzle. This gas jet momentum further increases the bolt velocity. Since it is difficult to calculate this gas momentum, its value is usually determined empirically as a function of bullet muzzle velocity:

Blowback Submachine Gun Cycle Calculations

A. Cartridge: 9x19mm Parabellum

Bullet weight: 7.50 grams

Powder weight: 0.43 gram

Muzzle velocity: 400 m/sec.*

*This is the value of a military load measured in a 250mm barrel; hence it will be used instead of the values given for commercial ammo.

B. Barrel Length: 250mm

C. Bolt Weight: 600 grams

D. Bolt Stroke: 150mm

E. Closing Spring Initial Load: 3.0 Kg

F. Assumptions:

1. Recoil spring retarding force prior to muzzle exit = 0.
2. Bolt friction = 0.
3. Bolt is stationary at ignition time, i.e., no advanced primer ignition.
4. Translation of spring mass is neglected.
5. Bolt energy at the end of stroke = 0.
6. No fluted chamber and/or lubricated ammo is used.

The calculation proceeds as follows:

from the maximum bolt momentum

maximum bolt momentum = bolt weight X maximum bolt velocity

= bullet weight X muzzle velocity + 1430 X powder weight

where 1430 is a factor when weights are in grams and velocities in m/sec., calculate the maximum bolt velocity V_b

$$V_b = \frac{\text{bullet weight (gram)} \times \text{muzzle velocity (m/sec)} + 1430 \times \text{powder weight}}{\text{bolt weight (gram)}}$$

$$V_b = \frac{7.50 \times 400 + 1430 \times 0.43}{600} = 6.0 \text{ m/sec.}$$

The maximum bolt energy is:

$$E_b = \frac{\text{bolt weight (Kg)}}{2g} \times (\text{bolt velocity - m/sec})^2$$

but the bolt energy is to be absorbed fully by the closing spring as per design parameters, hence

Energy of bolt = Energy of spring and (continued at top of opposite page)

$$\frac{\text{bolt weight}}{2g} \times (\text{bolt velocity})^2 = \frac{F_1 + F_2}{2} \times \text{bolt stroke}$$

solving this equation for F_2

$$F_2 = \frac{\text{bolt weight (Kg)} \times \text{bolt velocity (m/sec)}^2}{g \times \text{bolt stroke (m)}} - F_1$$

substituting values

$$F_2 = \frac{0.6 \times 6.0 \times 6.0}{9.80 \times 0.06} - 3.0 = 33.7 \text{ Kg}$$

The time necessary for the bolt to move from closed (forward) to full rear position is

$$T = \frac{\text{bolt weight (Kg)} \times \text{bolt velocity (m/sec)}}{3g} \left(\frac{1}{F_1} + \frac{2}{F_2} \right)$$

substituting values

$$T = \frac{0.6 \times 6.0}{3 \times 9.80} \times \left(\frac{1}{3.0} + \frac{2}{33.7} \right) = 0.048 \text{ sec.}$$

the cyclic rate, by definition is

$$CR = \frac{60}{2T} = \frac{30}{T} = \frac{30}{0.048} = 625 \text{ rds/min.}$$

momentum of gas jet = $k \times (\text{mass of powder charge}) \times (\text{bullet muzzle velocity})$

where k is a constant for a given cartridge type as shown below:

cartridge type	k
some shotshells	0
pistol & carbine	1.25
high power rifle	2.00

For practical computations of the above type the gas momentum may be neglected.

It must be emphasized that all above calculations are based on the use of a slide rule only since the accuracy is adequate for the purpose.

After satisfying himself that the selected design parameters are safe and reasonable, the designer is free to start the basic layout of the submachine gun.

Firing Pins

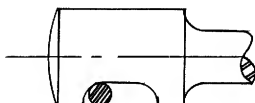
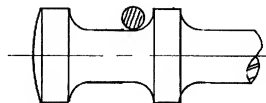
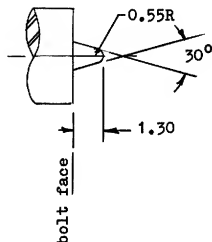
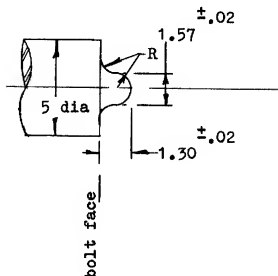
SMG firing pins are usually fixed in the bolt face. This means that the firing pin tip is in contact with the primer as soon as the cartridge is picked up from the magazine by the bolt. After the cartridge is seated in the chamber, the bolt continues its forward travel, driving the firing pin tip into the primer cup.

Typical firing pin forms and dimensions are shown at the top of page 26.

Criteria To Be Considered In The Extractor Design

1. *Sufficient Area At Rim Contact.* The area should be large enough to prevent the extractor from shearing off the cartridge rim and/or shearing off the extractor rim. Since the depth of the extractor rim is controlled by the depth of the cartridge

Typical SMG Firing Pins



Firing pin form requiring turning operations only.

Firing pin form requiring turning and milling operations.

rim, the rim contact areas becomes a function of extractor width only.

A rim contact area of .010 in.² is considered ample.

2. *Cross Section Area.* For optimum operation the extractor shank and/or other retaining member should be able to withstand a tensile load of 1500 lbs. Since the yield strength of material is known, the cross-section area can be readily computed.
3. *Retaining Area.* This should be sufficient to

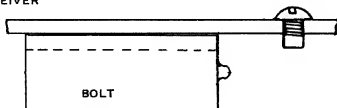
keep the extractor material below the yield point during extraction, i.e., should withstand a tensile load of approximately 1500 lbs.

4. *Spring Preload.* The extractor spring should be preloaded to the extent of keeping the extractor engaged in the cartridge rim during bolt opening. On automatic weapons with a rotating bolt the centrifugal force created tends to unlock the extractor from the cartridge.

Basic Ejector Types Used In Blowback SMG's

RECEIVER

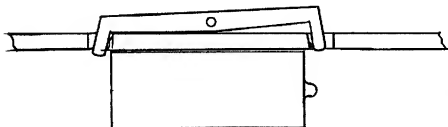
FIXED EJECTOR



FEATURES:

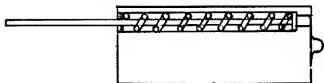
Simple, reliable, requires slot in bolt, produces violent ejection of fired cases.

SEMI-FIXED EJECTOR



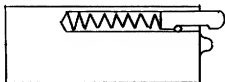
Reliable, requires opening in receiver wall, interferes with closing spring.

IMPACT-ACTUATED EJECTOR



Located in bolt, complex construction, requires positive rear impact.

SPRING ACTUATED

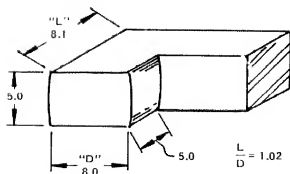
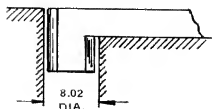


Located in bolt, independent of bolt travel, always acting on case, may interfere with cartridge pick-up & firing.

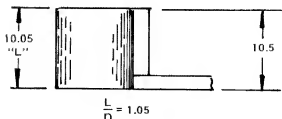
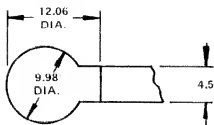
C-A rim contact area
C-B retaining area

L cross-section area

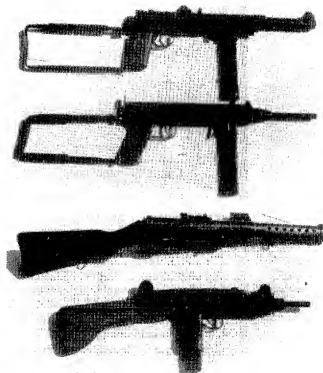
SCHMEISSER MP-40



STEYR MP-34 SOLOTHURN



Typical blowback SMG extractor types and relative dimensions are shown above.



No matter what their country of origin, caliber or exterior appearance, all simple blowback submachine guns encompass the same basic design problems and performance characteristics. From top to bottom: Swedish M-45 (Carl Gustaf), Danish Madsen M-1950, Steyr MP-34 Solothurn, Israeli Uzi with wooden stock.

The story of submachine guns would be incomplete without mentioning multi-projectile cartridge/weapon systems. Since the beginning of firearms, the desire to improve the hit probability went in the direction of:

- Rapid/automatic fire.
- Multiple projectiles.

Double loading of muskets with two or more bullets is common through the annals of history up to and into the Civil War. Duplex and triplex (two and three bullets respectively) loads were tested and used in the .30-06 cartridge as recently as the late 1950's. However, the classic multi-projectile cartridge is the shotshell loaded with large size pellets. Starting with the picturesque blunderbuss, it evolved into the modern repeating shotgun loaded with buckshot shells.

Shotguns were used by the U.S. Army in World War I trenches and World War II Pacific jungles. In Vietnam the point man (first in line) of a patrol



WINCHESTER-WESTERN "LIBERATOR" SPECIFICATIONS

BORE:	16 ga. (.670 in.)
CAPACITY:	Four rounds
EFFECTIVE RANGE:	60 meters
NUMBER OF BARRELS:	Four
CHOKE:	Full
LENGTH OF BARRELS:	13½ inches
OVERALL LENGTH:	18 inches
WEIGHT:	7 lbs. (approx.)

GRIPS:	Full submachine gun type
STOCK:	Detachable metal shoulder stock
TRIGGER:	Squeeze type double action
FINISH:	Olive drab, epoxy resin, baked enamel (or as desired)
SIGHTS:	Post with painted rib for ready point of index
SLING:	Optional

usually carried a slide action shotgun loaded with 12 ga. 00 buck shells. Soldiers armed with the M-79 grenade launcher also carried an adaptor allowing them to fire 12 ga. 00 buck shells for close defense.

The effectiveness of a single 12 ga. shotshell loaded with 12 or 15 buckshot pellets against soft (human) targets at ranges up to 75 meters is as good or better than a 3 to 5 round burst from a submachine gun.

The question is raised: Why use submachine guns if the shotgun is so good? There are several reasons, some mentioned below:

1. The soft lead pellet without a jacket is classified by the Geneva Convention as a "dumdum" projectile. A prisoner caught with "dumdum" ammunition, be it a shotshell, soft nose revolver bullet or a rifle cartridge with the bullet tip filed off, may be shot on the spot by his angry captors.
2. The buckshot pellet has poor trajectory characteristics beyond the 75 meter range.

3. The buckshot penetration of any type of protective barrier, or body armor is very low.
4. The recoil of a standard size and weight shotgun firing a buckshot load is heavy. The "kick" against the shoulder is twice that of an M-1 service rifle of World War II era, firing a ball cartridge.
5. A shotgun is long and heavy when compared with a submachine gun, hence difficult to carry and store by such troops as paratroopers, tank crews, guerrillas, etc.

To improve the shotgun's effectiveness for military use the ammunition designers started loading shotshells with flechettes. A flechette is a small, nail-sized arrow. In length it may vary from 20 to 40mm, depending on the round in which it is used. Flechettes have been loaded in .45 ACP pistol cartridges, 12 ga. shotshells, 81mm mortar shells, 2.75 inch rockets and artillery projectiles of 90-120mm caliber, called APERS.

Due to its advantageous form a flechette has a range and penetration exceeding that of a shot

pellet. Because it is fin stabilized, it tumbles easily at impact and/or penetration, causing severe wounds. Unfortunately a flechette also has serious drawbacks. As the range increases, so does the dispersion of the flechette cluster until the pattern becomes so wide as to cause "windows". A "window" in this sense is an area which is free of any single pellet/flechette and which allows the target to remain unharmed even if the shot was aimed correctly.

While a flechette or rocket shell has an effective range of 300 to 400 meters, a shotgun flechette load is effective at 75 meters maximum.

The effectiveness of a buckshot load against unprotected targets has been widely recognized and accepted. The FBI and several metropolitan police departments arm their personnel with shotguns. Various models have been modified or specifically designed for law enforcement, security and military use. The most innovative and effective of these designs is the Winchester-Western "Liberator", a four-barreled, compact weapon.

With the increased use of armored vests and other body armor the buckshot load loses its effectiveness when compared to a submachine gun burst.



SECTION II.

Ammunition

External Ballistics Of Various Submachine Gun Cartridges

RANGE
(In Meters)

TRAJECTORY ABOVE & BELOW LINE OF SIGHT
(In Millimeters)

.30 M1 Carbine

7.62x24mm

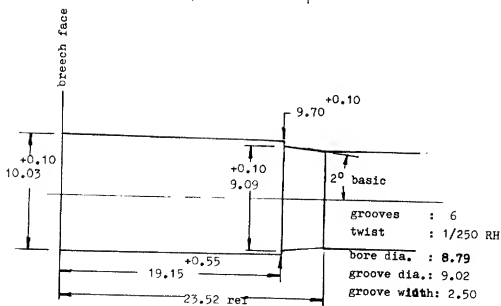
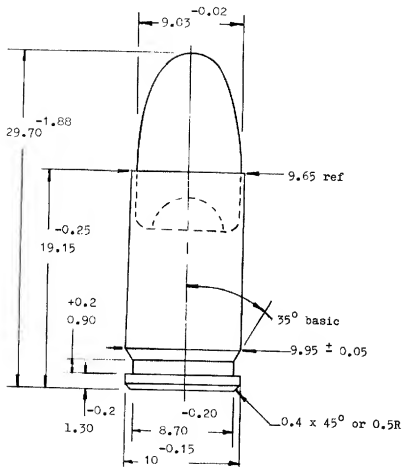
9x19mm

.45 ACP

25			0	0
50	25 80		100 -4	230 -52
100	0 95	75	0 -240	0 -300
150	0	0		

Re: Iron sights, front sight 20mm above bore

9mm Parabellum

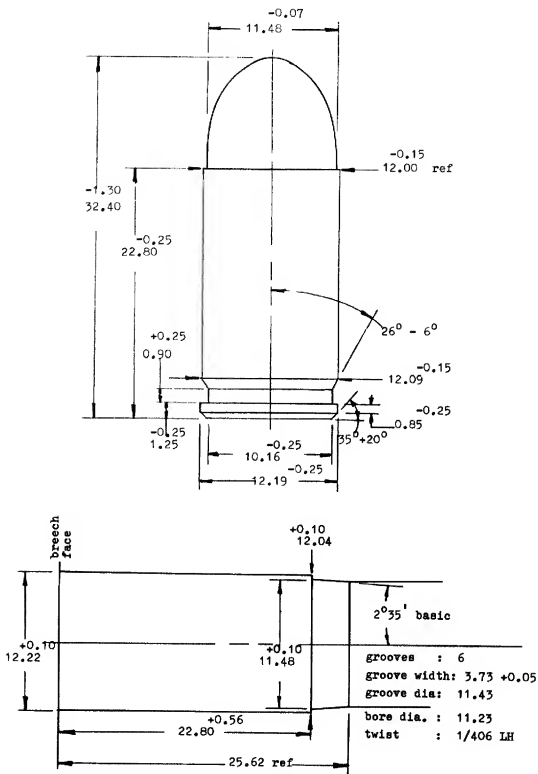


Note: Only basic chamber dimensions are indicated; clearances for extractor grooves and feed cone depend on the specific barrel design.

9mm Parabellum

PRESSURE:	Maximum average, Kg/cm ² : 2320 Maximum variation, Kg/cm ² : 620 Maximum probable lot mean, Kg/cm ² : 2400
VELOCITY:	At 5 meters, m/sec. : 343 ± 14 Equivalent to $V_0 = 350$ m/sec.
ACCURACY:	Range in meters: 25 Targets : five (5) 5-shot groups Maximum average extreme spread in mm, 65 + 13
BULLET PUSH:	Minimum individual, Kg : 11.4
BULLET PULL:	Minimum individual, Kg : 13.6
SENSITIVITY, EMPTY PRIMED CASE:	100% Fire 205.7mm H + 5S 233.7mm max. H - 2S 50.8mm min. 0% fire 50.8mm
COMPONENTS —	
CASE:	70/30 cartridge brass
BULLET:	Type: ball Jacket: 90/10 brass or clad steel Core: antimonial lead Bullet weight, in grams: 7.45 ± 0.10
POWDER:	Smokeless WC500 or equivalent Charge: $0.43 + 0.02$ gram
PRIMER:	Small pistol type, non-corrosive, seated flush or a maximum of 0.25mm below head
NOTES:	Case mouth and primer annulus may be waterproofed with suitable lacquer. All tests performed in accordance with standard ballistic laboratory procedures and equipment.

.45 ACP

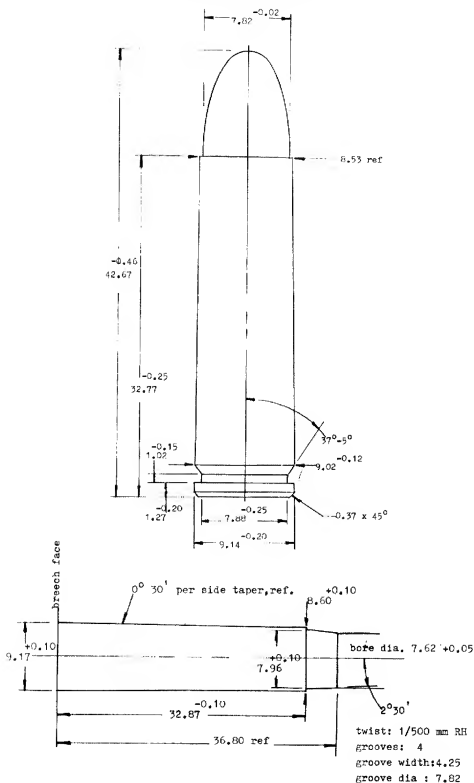


Note: Only basic chamber dimensions are indicated; clearances for extractor grooves and feed cone depend on the specific barrel design.

.45 ACP

PRESSURE:	Maximum average: 1265 Kg/cm ² Maximum extreme variation: 436 Kg/cm ² Maximum probable lot mean: 1322 Kg/cm ²
VELOCITY:	At 5 meters: 258 ± 13.7 m/sec. Equivalent to V ₀ = 260 m/sec.
ACCURACY:	Range in meters: 50 Targets: five (5) 5-shot groups Maximum average extreme spread: 65 + 13mm
BULLET PUSH:	Minimum individual: 22.8 Kg
BULLET PULL:	Minimum individual: 18.0 Kg
SENSITIVITY, EMPTY PRIMED CASE:	100% Fire 289.6mm H + 5S 322.6mm H - 2S 76.2mm 0% Fire 76.2mm
COMPONENTS —	
CASE:	70/30 brass
BULLET:	Type: metal case Jacket: 90/10 brass Core: antimonial lead Bullet weight, in grams: 14.89 ± 0.10
POWDER:	Smokeless WC235 or equivalent Charge: 0.38 ± 0.02 gram
PRIMER:	Large pistol type, non-corrosive, seated flush or a maximum of 0.25mm below head
NOTES:	Case mouth and primer annulus may be waterproofed with suitable lacquer. All tests performed in accordance with standard ballistic laboratory procedures and equipment.

.30 M1 Carbine

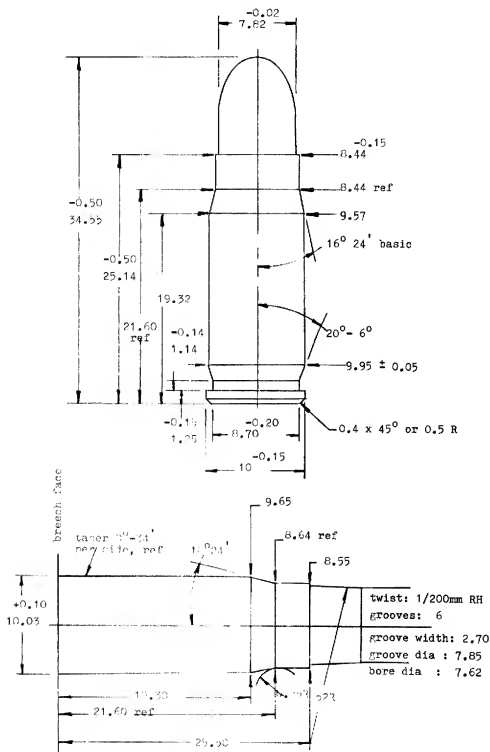


Note: Only basic chamber dimensions are indicated; clearances for extractor grooves and feed cone depend on the specific barrel design.

.30 M1 Carbine

PRESSURE:	Maximum average: 2810 Kg/cm ² Maximum extreme variation: 724 Kg/cm ² Maximum probable lot mean: 2900 Kg/cm ²
VELOCITY:	At 5 meters: 596 ± 15 m/sec. Equivalent to V ₀ = 604 m/sec.
ACCURACY:	Range in meters: 100 Targets: three (3) 10-shot groups Maximum average extreme spread: 77 + 13mm
BULLET PUSH:	Minimum individual: 22.8 Kg
BULLET PULL:	Minimum individual: 22.8 Kg
SENSITIVITY, EMPTY PRIMED CASE:	100% Fire 406.4 mm H + 5S 406.4mm H - 2S 76.2mm 0% Fire 76.2mm
COMPONENTS —	
CASE:	70/30 brass
BULLET:	Type: ball Jacket: 90/10 brass or clad steel Core: antimonial lead Bullet weight, in grams: 7.12 ± 0.20
POWDER:	Smokeless WC295 or equivalent Charge: 0.90 ± 0.02
PRIMER:	Small rifle type, non-corrosive, seated flush or a maximum of 0.20mm below head
NOTES:	Case mouth and primer annulus may be waterproofed with suitable lacquer. All tests performed in accordance with standard ballistic laboratory procedures and equipment.

7.62x24mm Mauser (.30 Mauser)

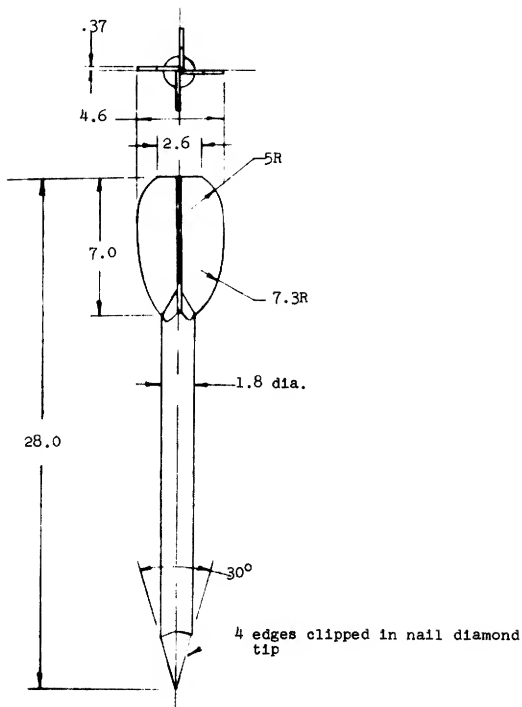


Note: Only basic chamber dimensions are indicated; clearances for extractor grooves and feed cone depend on the specific barrel design.

7.62x24mm Mauser (.30 Mauser)

PRESSURE:	Maximum average: 1970 Kg/cm ² Maximum extreme variation: 620 Kg/cm ² Maximum probable lot mean: 2050 Kg/cm ²
VELOCITY:	At 5 meters: $V_5 = 422 \pm 15$ m/sec. Equivalent to $V_0 = 430$ m/sec.
ACCURACY:	Range in meters: 50 Targets: five (5) 5-shot groups Maximum average extreme spread: 90 + 13mm
BULLET PUSH:	Minimum individual: 22.8 kg
BULLET PULL:	Minimum individual: 22.8 Kg
SENSITIVITY, EMPTY PRIMED CASE:	100% Fire 205.7mm H + 5S 233.7mm max. H - 2S 50.8mm min. 0% Fire 50.8mm
COMPONENTS —	
CASE:	70/30 cartridge brass, weight 4.5 grams
BULLET:	Type: ball Jacket: 90/10 brass or clad steel Core: antimonial lead Bullet weight in grams: 5.60 ± 0.20 Bullet length: 14mm
POWDER:	Smokeless, Charge: 0.42 ± 0.02 gram
PRIMER:	Small pistol type, non-corrosive, seated flush or a maximum of 0.20 mm below head
NOTES:	Case mouth and primer annulus may be waterproofed with suitable lacquer. All tests performed in accordance with standard ballistic laboratory procedures and equipment.

Flechette



type

A

B

material
heat treat
finish

mild steel
none
black oxide

medium carbon steel
harden
Cd- dip or equiv.



SECTION III.

Working Drawings – Sten & PPSH 41

Note: All dimensions are metric unless otherwise specified.
See metric/U.S. standard conversion chart on page 93.



Sten Mk II

PARTS LIST

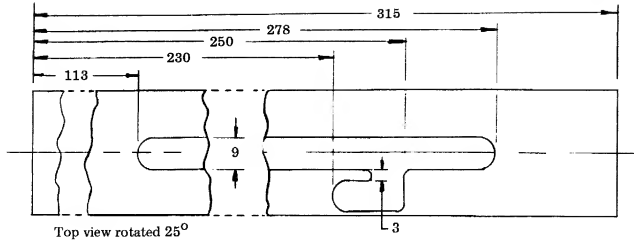
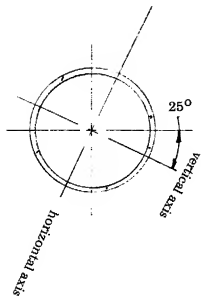
- | | |
|---------------------------------------|--|
| 1. Barrel | 24. Sear |
| 2. Barrel sleeve | 25. Sear spring |
| 3. Barrel sleeve lock | 26. Sear pin |
| 4. Barrel sleeve lock spring | |
| 5. Front sight | 27. Bolt |
| 6. Barrel bushing | 28. Firing pin |
| 7. Receiver tube | 29. Extractor |
| 8. Receiver cap | 30. Extractor spring |
| 9. Trigger housing | 31. Extractor pin |
| 10. Butt stock assembly: stock tubing | 32. Bolt handle |
| butt plate | |
| stock grip | 33. Closing spring |
| stock ring | 34. Closing spring cup |
| | 35. Trigger housing cover |
| 11. Magazine housing | 36. Trigger housing cover screw (2) |
| 12. Magazine housing spacer | |
| 13. Magazine housing spacer screw | 37. Magazine housing |
| 14. Magazine latch | 38. Magazine follower |
| 15. Magazine latch spring | 39. Magazine spring |
| | 40. Magazine spring latch |
| 16. Trigger | 41. Magazine bottom |
| 17. Trigger spring | |
| 18. Trigger pin | 42. Rear sight |
| 19. Disconnecter | |
| 20. Disconnecter pin | NOTES: |
| 21. Selector | 1. Bolt stopping surface on barrel is 1mm forward of magazine well slot. |
| 22. Selector spring | 2. Bolt stroke is 135mm. |
| 23. Selector plunger (2) | |

STEN Mk II SPECIFICATIONS

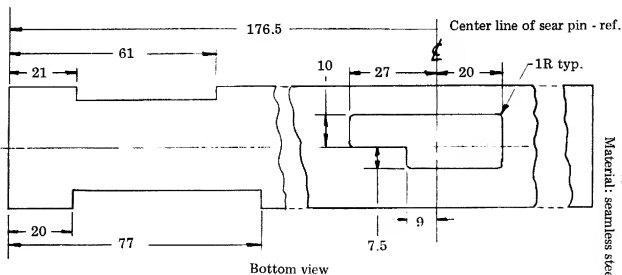
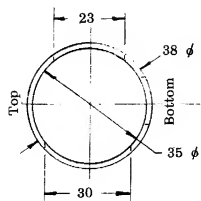
1. Cartridge:	9mm Parabellum	
	Bullet weight	116 grains
	Powder weight	6 grains
	Muzzle velocity	1400 ft./sec.
2. Recoil Spring:	Wire diameter	0.067 in.
	Spring OD	1.00 in.
	Active coils	15
	Free length	9.40 in.
	Initial length	6.80 in.
	Final length	3.20 in.
	Work stroke	3.60 in.
3. Bolt:	Weight	1.327 lb. (9290 grains)
	(including extractor)	
	Cocking handle	0.077 lb. (540 grains)
Total recoiling weight:		1.404 lb. (9830 grains)
	Bolt maximum dia.	1.381 in.
	Bolt overall dia.	5.75 in.
	Bolt body length	4.21 in.

SUGGESTED STEN MANUFACTURING MODIFICATIONS

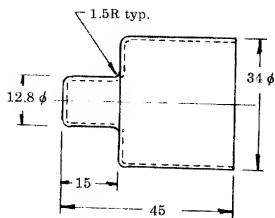
- Select suitable lightwall steel tubing which is commercially available. For example, a fence post pipe (galvanized) is 38.5mm OD and 35.0mm ID, most suitable for use as a receiver.
- Eliminate barrel sleeve.
- Weld barrel bushing into the front end of the receiver for simple, permanent assembly.
- Turn barrel blank OD (outside diameter) without any shoulder, fit the barrel in the bushing by sliding fit.
- Fasten the barrel in the bushing by two roll pins of 3/16" diameter, or equivalent.
- Turn the bolt OD to fit the receiver ID.
- The external portion of the cocking handle (sticking out of the receiver) may be a straight 8.8mm OD, the same as the inside.
- The trigger housing cover acts only as a guard against dirt entering the trigger assembly. This cover can be eliminated or made from plastic.
- All pins can be roll pins of standard commercial size, or pieces of drill rod.
- All springs can be of a standard commercial size.
- Trigger material may be aluminum or plastic, side tabs may be replaced by spacers or washers to keep the trigger located neutrally.
- 1-1/4" diameter nominal size galvanized pipe, schedule 40 is suitable for a modified receiver:
 OD: 42.2mm
 ID: 35.05mm
 Wall thickness: 3.55mm
 Note: A 1" galvanized pipe fits loosely inside a 1-1/4" pipe and can be welded as a filler-spacer where needed.



Scale: .87 : 1

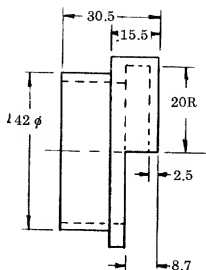


Receiver tube
Material: seamless steel tubing



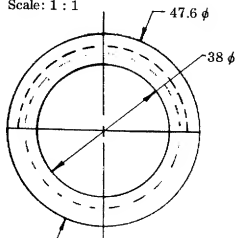
Main spring cap
Material: 1mm stock

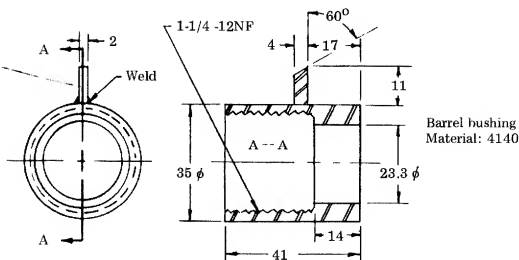
Scale: 1 : 1



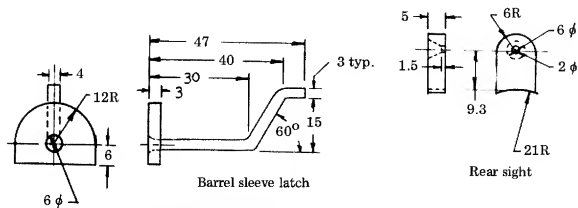
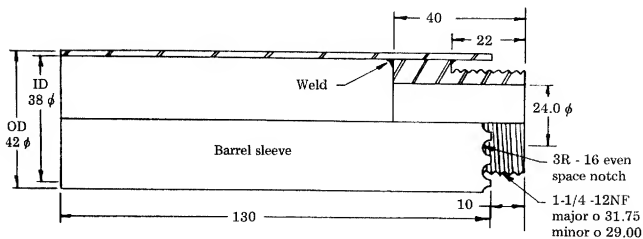
Receiver rear end bushing
Material: AISI 1010 or equivalent

Scale: 1 : 1



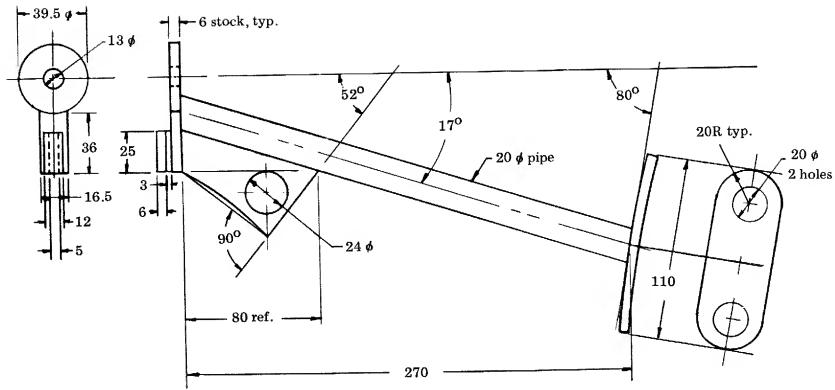


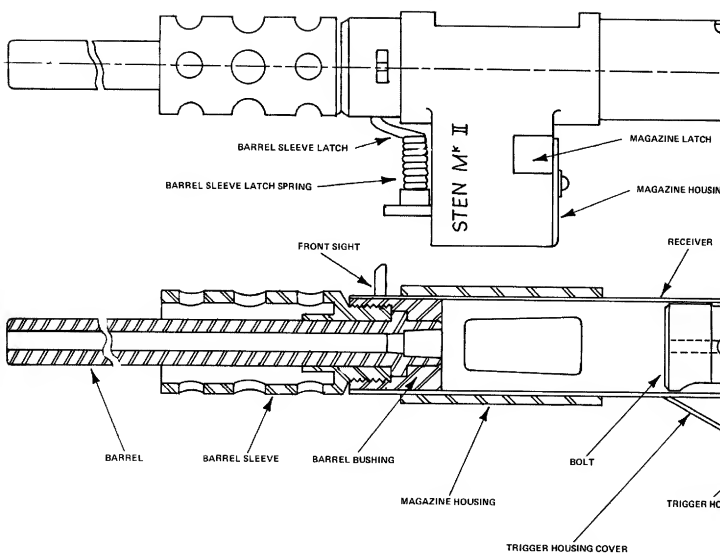
Scale: .87 : 1



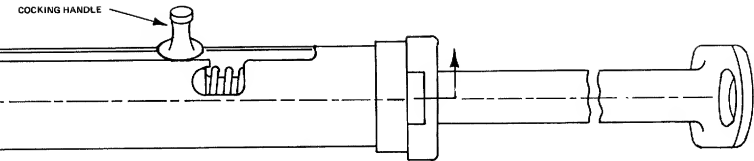
Note: Stake at assembly
with magazine housing

Butt-stock assembly
 Material: low carbon steel
 or aluminum, welded construction

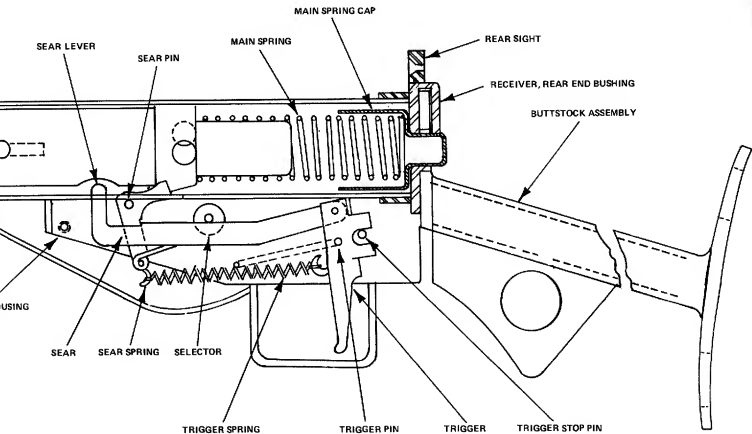




Sten Mk II

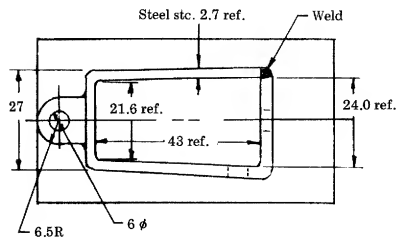
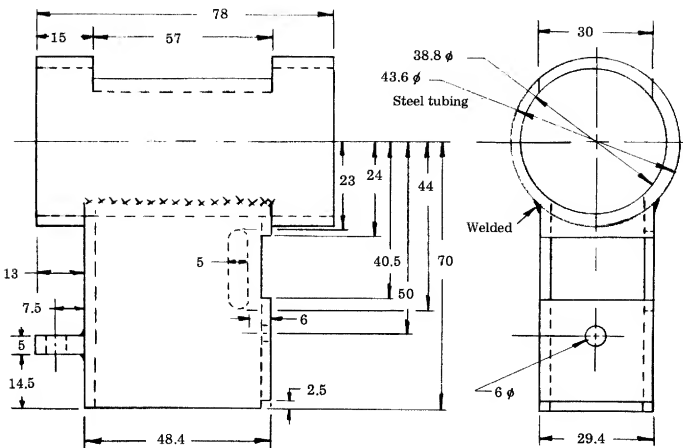


SPACER



Magazine housing
Material: as noted

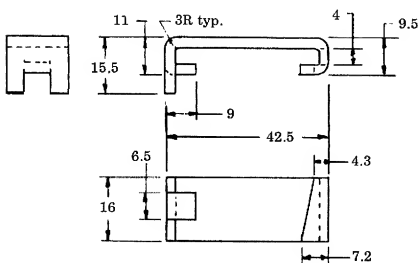
Scale: 1 : 1



Magazine latch

Material: AISI 1010 or equivalent
2.7mm stock. Case harden 0.1mm deep

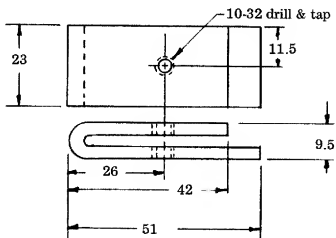
Scale: 1 : 1



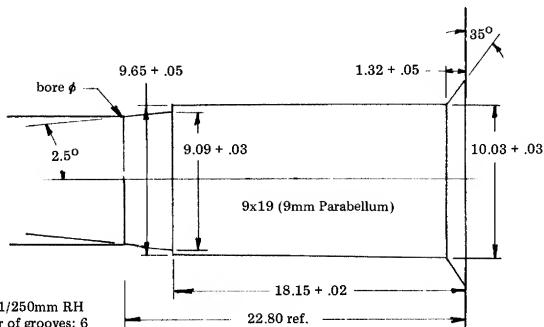
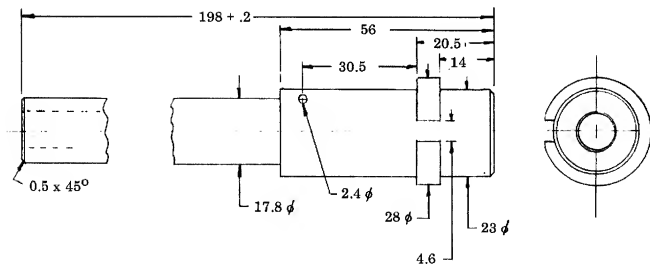
Magazine housing spacer

Material: AISI 1010 or equivalent
3mm stock. Heat treat: none

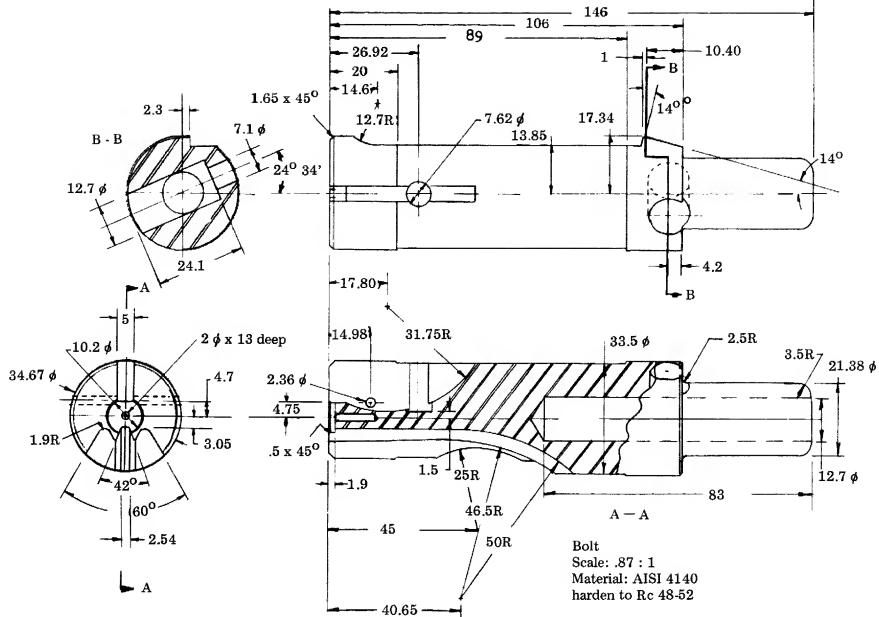
Scale: 1 : 1



Barrel
Material: AISI 4140
Harden to: Br 255-277

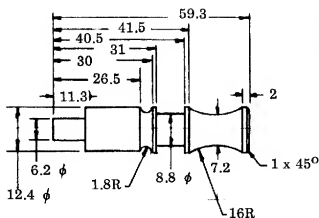
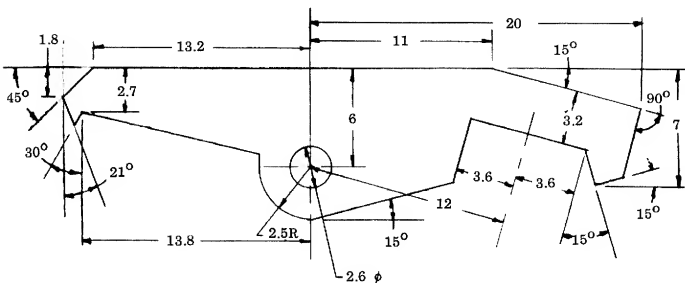


Twist: 1/250mm RH
Number of grooves: 6
Groove width: $2.5 + .02$
Bore diameter: $8.84 + .02$
Rifling diameter: $9.06 + .05$

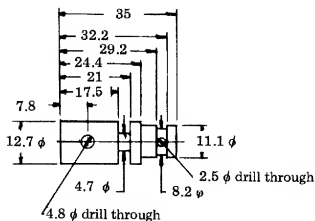


Extractor
Scale: 4.5 : 1

Material: AISI 1040 or equiv., stock 4.7 wide
harden to: Rc 48-52

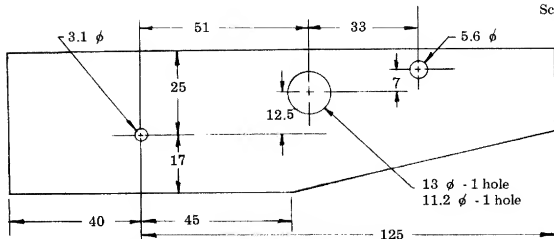


Bolt handle
Scale: .87 : 1
Material: mild steel
Heat treat: none

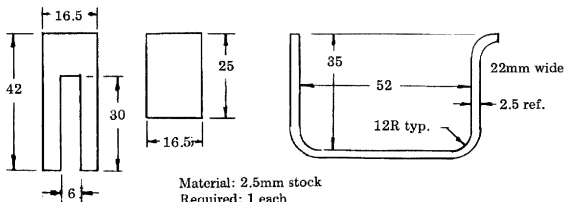


Selector
Scale: .87 : 1
Material: mild steel
Heat treat: none

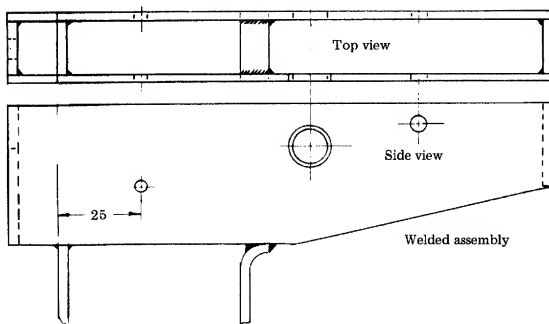
Trigger housing
Scale: .87 : 1



Material: 2.5mm stock
Required: 2

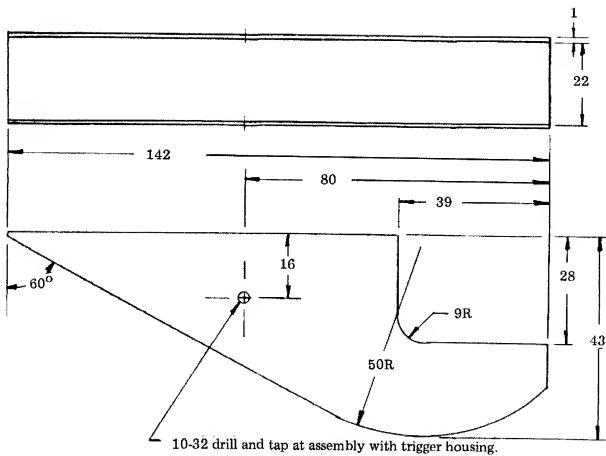


Material: 2.5mm stock
Required: 1 each

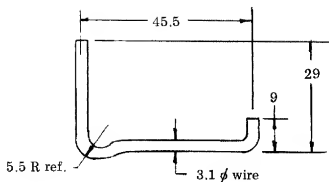


Trigger housing cover
 Material: 1mm stock, formed
 Required: 1

Scale: 1 : 1

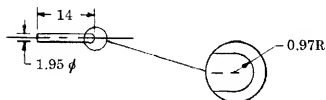


All Sten screws are 10-32 thread, round head type. Trigger housing screws (2) are 13mm long.



Trigger pin

Note: Trigger pin may be substituted by spring pin 3.1 ϕ by 26 long.



Firing pin
Material: Drill rod
Harden to Rc 50

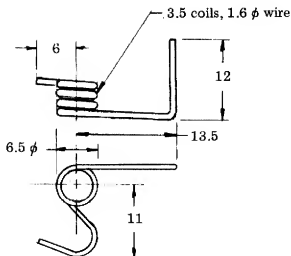
PINS (Spring pins)

USE	DIAMETER	LENGTH
Extractor	2.5	25
Sear	5.5	24

SPRINGS

USE	Wire dia.	Coil OD	Free length	Number of coils	Coil ends	SUBSTITUTE*
Extractor	1	7.1	12	5.5	Sq.	LC-040C-4
Magazine latch	1	8.7	15.5	6	Gr.	LC-040C-6
Closing	1.6	26.5	245	17	Sq.	
Trigger	0.7	4.6	57	72	Extension spring loops	LE-026B-7 or LE-026C-8
Selector	0.45	4.6	14	8	Gr.	LC-018B-6
Barrel sleeve latch	1	8.7	35	15	Sq.	

Sear spring, formed
substitute LT-059K-1-R



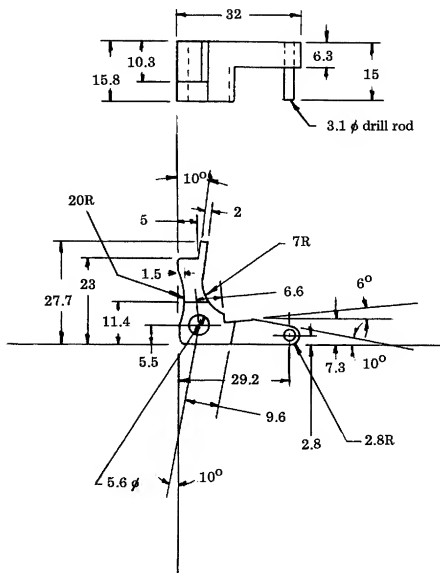
*Lee Spring Company, 30 Main St., Brooklyn, NY 11201; catalog No. 112/1970

Sear

Material: AISI 4140 or equivalent

Scale: 1 : 1

Harden to Rc 55



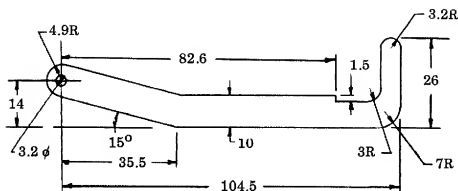
Disconnecter

Material: AISI 1040 or equivalent,

2.5mm stock

Case harden: 0.1mm deep

Scale: .87 : 1



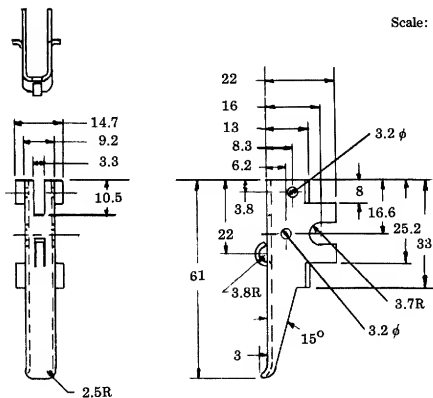
Trigger

Material: AISI 1010 or equivalent,

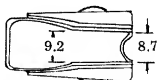
1.6mm stock

Heat treat: none

Scale: .87 : 1



Top view

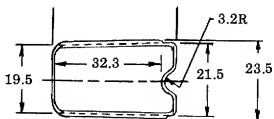
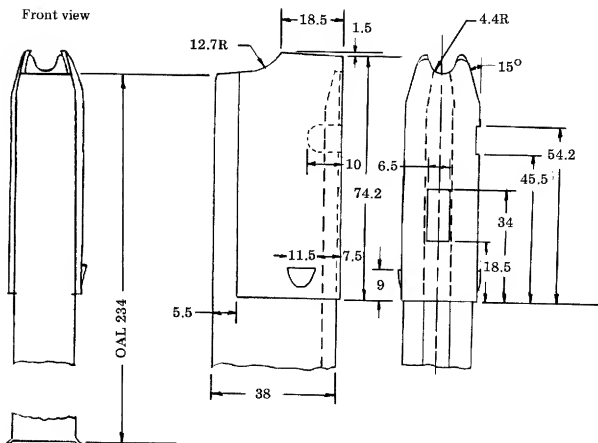


Magazine

Material: 1mm steel stock

Scale: 8.7 : 1

Rear view

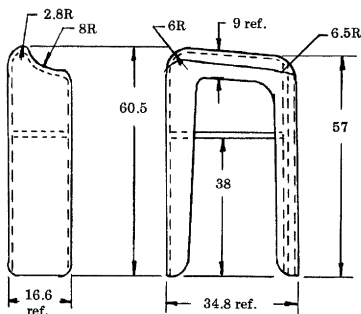
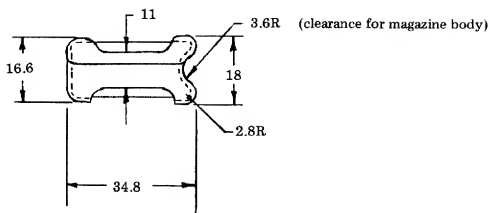


Bottom view

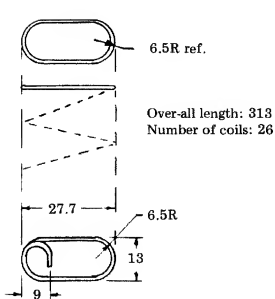
Magazine follower

Material: low carbon steel

Scale: 1 : 1

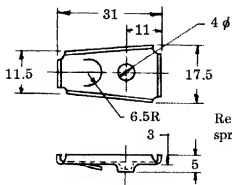


Note: The magazine follower is a complex stamping made on a progressive die. To make a follower in a simpler way is to follow the Degtyarev DP LMG approach — using a dummy round as the last one in the magazine. Thus a simple, flat follower with a dummy round soldered and/or screwed to it will replace a complicated stamping.



Magazine spring
Material: Music wire 1.5mm dia.

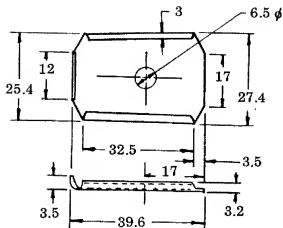
Scale: .87 : 1



Magazine bottom retainer
Material: 1mm mild steel

Scale: .87 : 1

Retaining lip bent over magazine
spring tab at assembly



Magazine bottom plate
Material: 1mm mild steel

Scale: .87 : 1



PPSh 41

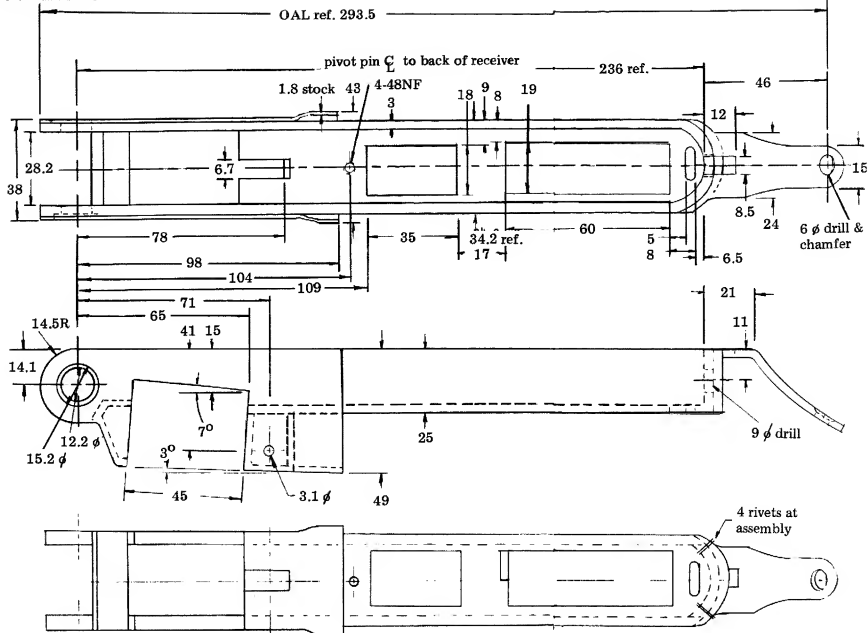
USE	PINS	
	PIN DIA. (mm)	PIN LENGTH (mm)
Magazine latch	2.8	38
Firing pin	4.0	32
Receiver latch	5.0	40
Rear sight	3.0	24
Magazine latch pivot	2.5	9

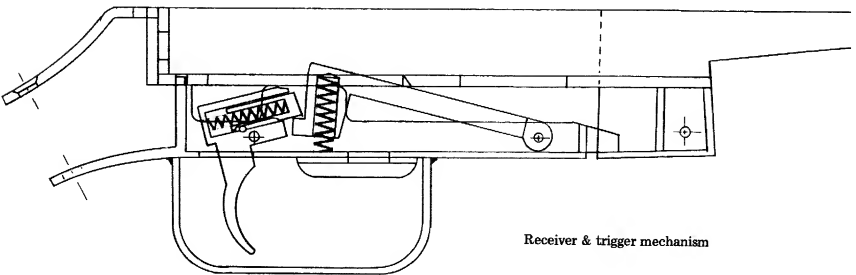
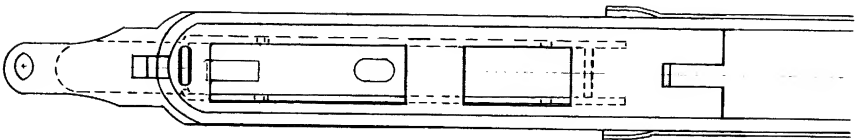
USE	SPRINGS			
	WIRE DIA. (mm)	SPRING OD (mm)	OAL (mm)	No. COILS
Trigger	0.7	4.5	11.5	7
Trigger plunger	0.6	4.3	35	25
Sear	0.8	6.4	35	15
Selector	1.0	8.3	13	6
Magazine latch	0.5	4.2	13	8
Main	0.91	6.86	200	74
Safety	0.5	3.5	6.5	4
Receiver latch	1.0	4.0	52	

USE		SCREWS		REQUIRED
		TYPE		
Sling plate	Wood	Flat head	6 ϕ	2
		Body	3 ϕ	
		Length	15	
Butt plate	Wood	Half round head	10 ϕ	2
		Body	6 ϕ	
		Length	25	
Receiver	Machine	Half round head	10 ϕ	1
		Body	5 ϕ	
		Length	40	

Receiver
Material: Steel

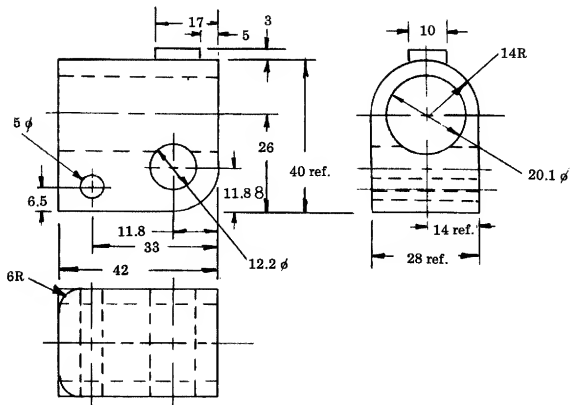
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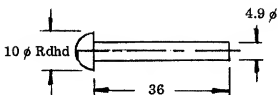


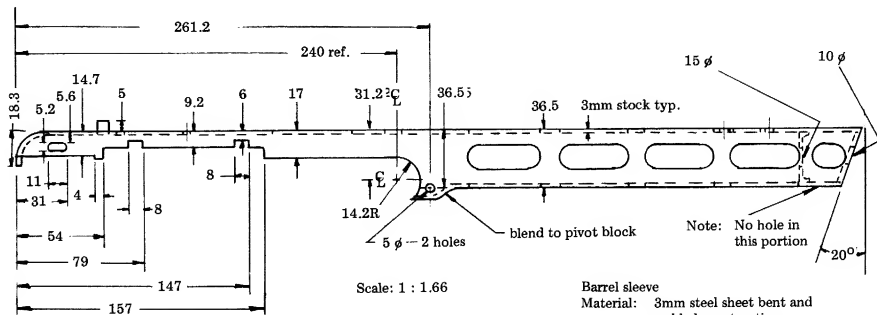
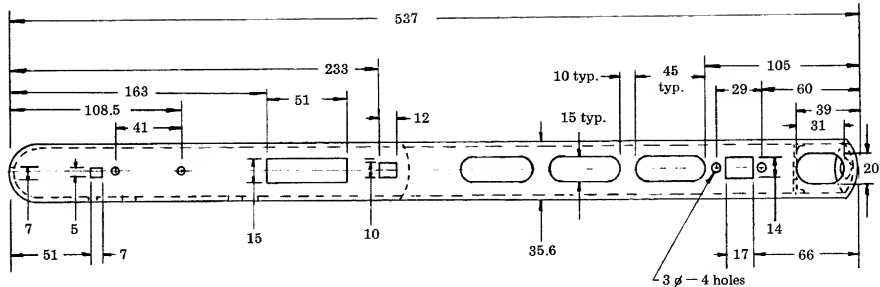
Receiver & trigger mechanism

Pivot block
Material: steel
Scale: 1 : 1



Barrel sleeve rivet
Material: steel
Scale: 1 : 1

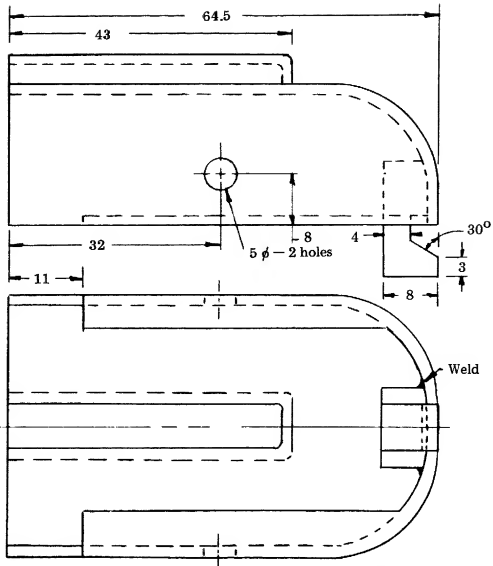
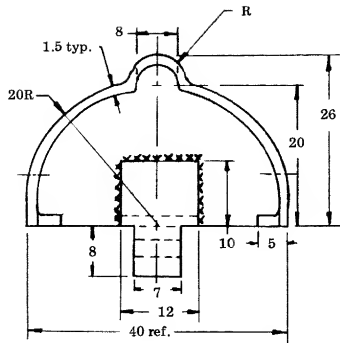




Scale: 1 : 1.66

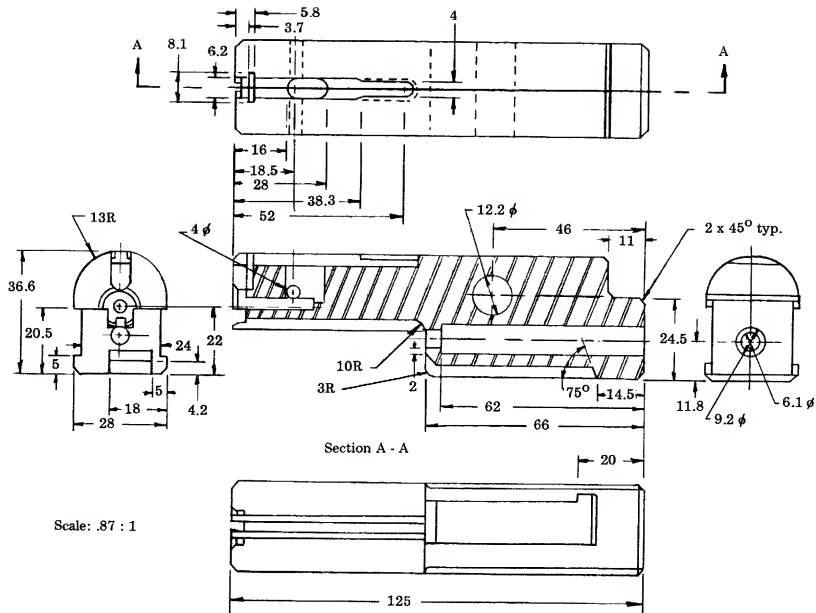
Barrel sleeve

Material: 3mm steel sheet bent and welded construction

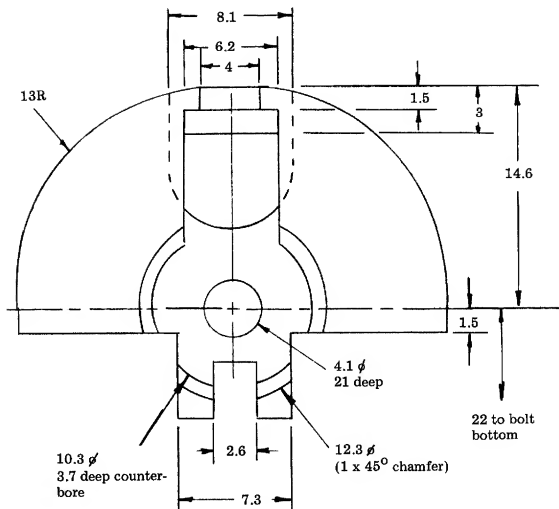


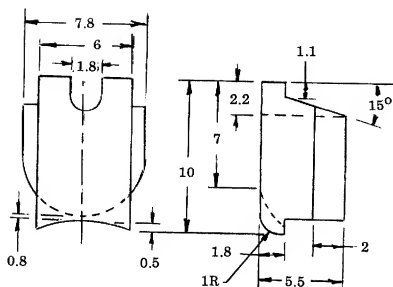
Receiver catch
Material: steel
Scale: 1.74 : 1

Bolt
Material: steel

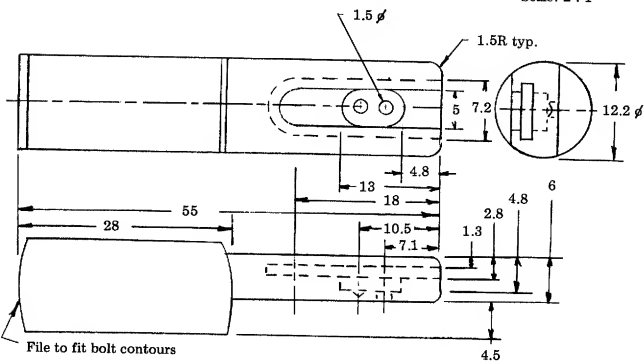


Bolt face detail

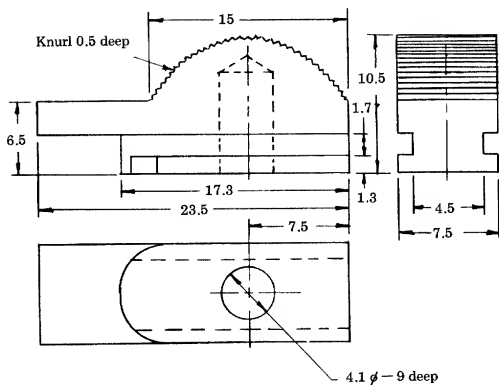




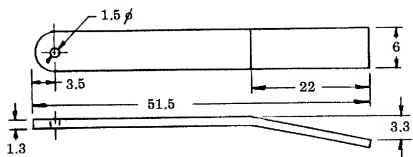
Extractor
Material: 4140 steel
Rc 52-55
Scale: 4 : 1



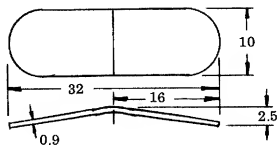
Bolt handle
Material: steel
Scale: 2 : 1



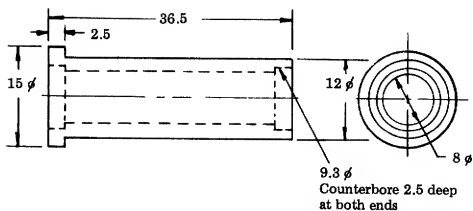
Safety
Material: Steel
Scale: 3.48 : 1



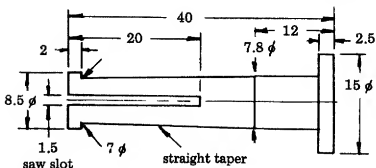
Extractor spring
Material: spring stock
Scale: 1.74 : 1



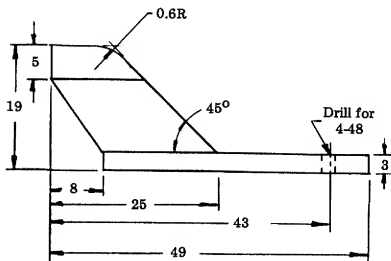
Rear sight spring
Material: spring stock
Scale: 1.74 : 1



Barrel pivot pin
Material: steel
Scale: 1.74 : 1

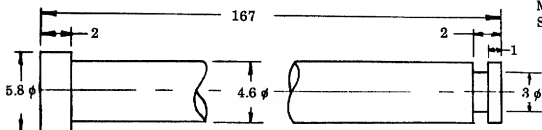


Barrel pivot pin lock
Material: steel
Scale: 1.74 : 1

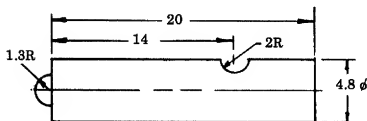
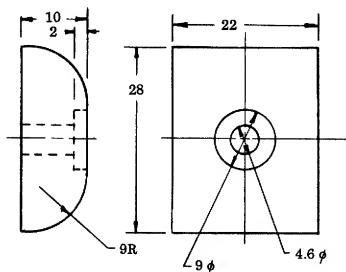


Ejector
Material: steel
Scale: 1.74 : 1

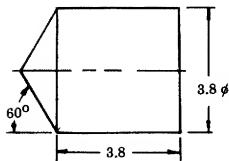
Main spring guide
Material: steel
Scale: 3.48 : 1



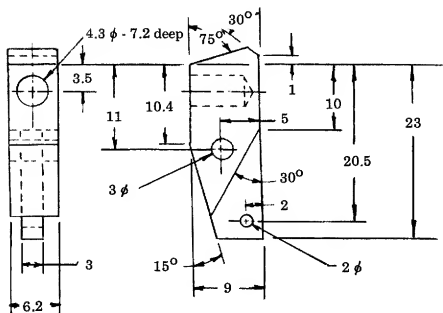
Bolt buffer
Material: plastic
Scale: 1.74 : 1



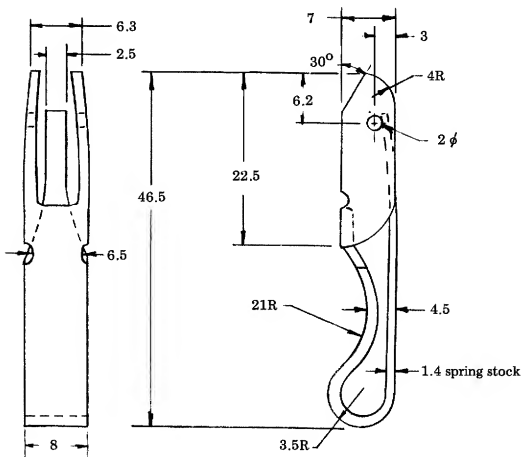
Firing pin
Material: 4140 steel
Rc 55-60
Scale: 3.48 : 1

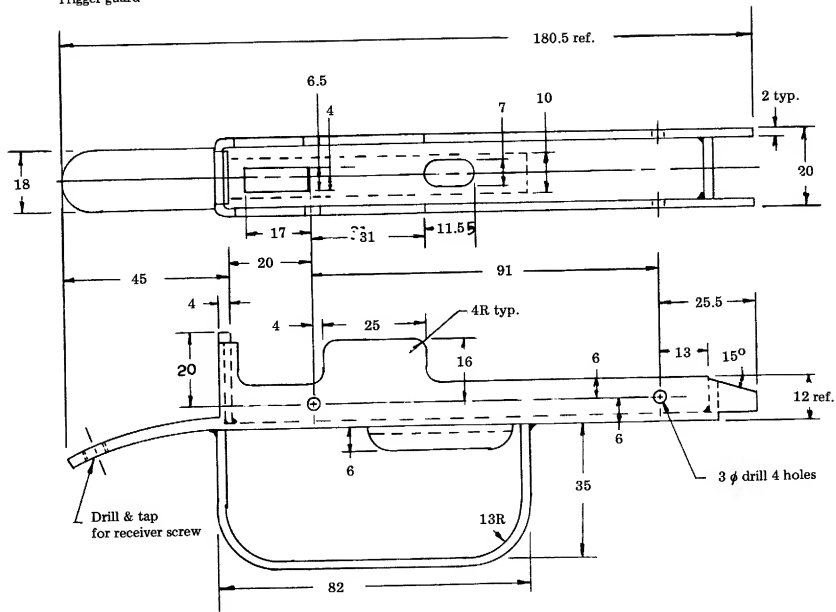


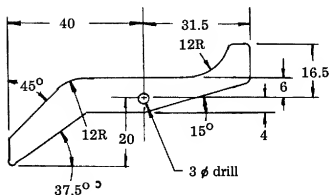
Safety plunger
Material: 4140 steel
Rc 55-60
Scale: 8.7 : 1



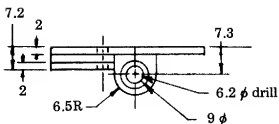
Magazine latch
Material: steel
Rc 50-55
Scale: 2:1



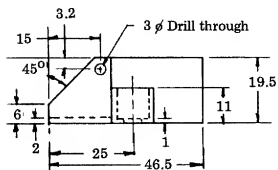




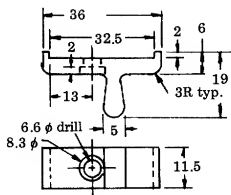
Disconnector
Material: 3mm thick steel strip
Scale: .87 : 1



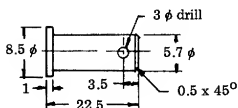
Selector housing
Material: steel
Scale: 1 : 1

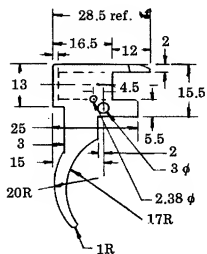


Selector
Material: steel
Scale: .87 : 1



Selector plunger
Material: steel
Scale: .87 : 1

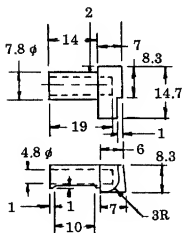




Trigger

Material: 4140 steel or equivalent

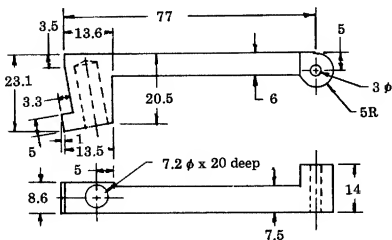
Scale: .87 : 1



Trigger plunger

Material: 4140 steel or equivalent

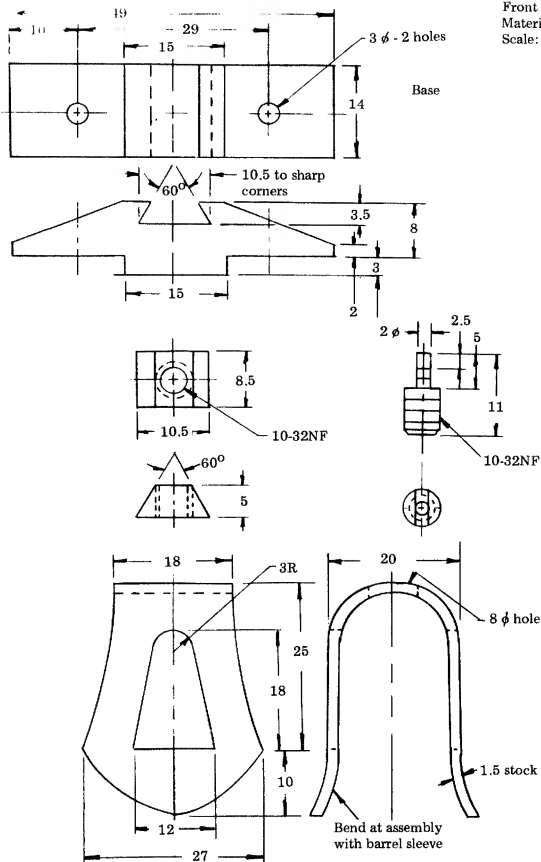
Scale: .87 : 1

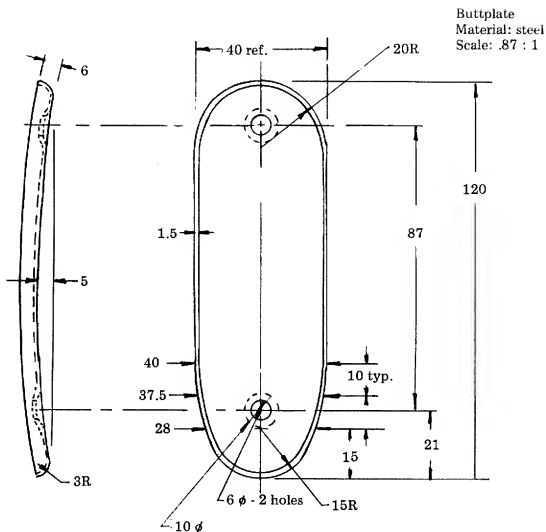


Sear

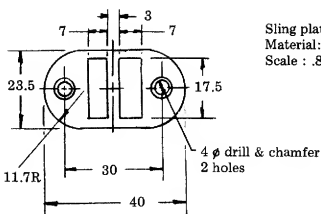
Material: 4140 steel or equivalent

Front sight
Material: steel
Scale: 1.74 : 1





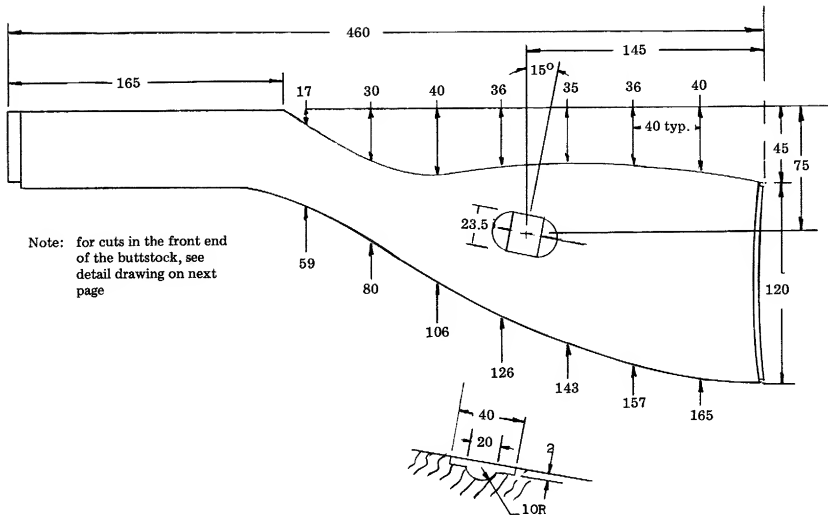
Buttplate screw
2 required
Half round head wood screw,
10 ϕ body 6 ϕ x 25 long



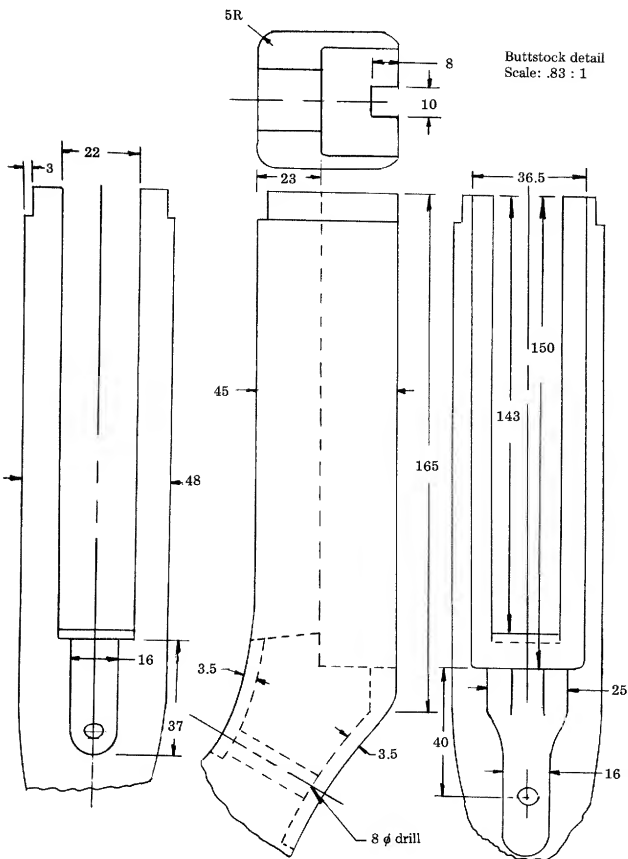
Sling plate
Material: steel stock 1.5mm
Scale : .87 : 1

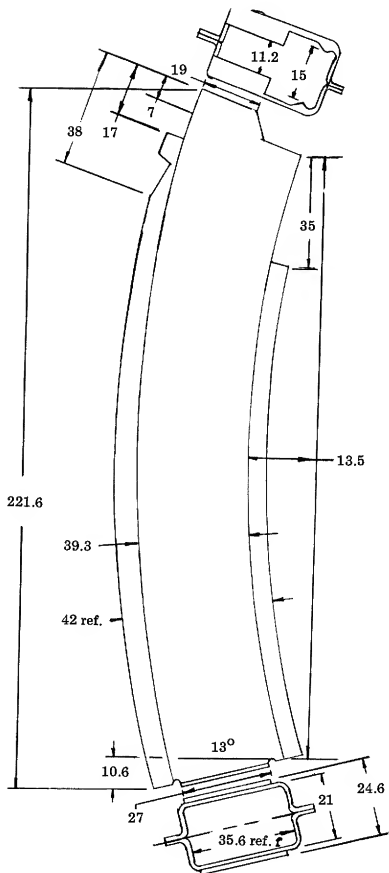
Sling plate screw
2 required
Flat head wood screw,
6 ϕ body, 3 ϕ x 15 long

Buttstock
Material: wood
Scale: .87 : 2



Note: for cuts in the front end of the buttstock, see detail drawing on next page



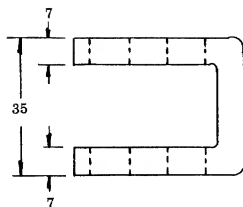


Magazine body

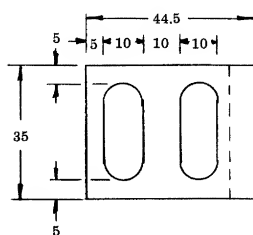
Material: 1mm steel sheet stock

Scale: .83 : 1

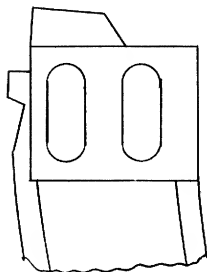




Magazine body filler
Material: steel



Note: welded to magazine
body at assembly

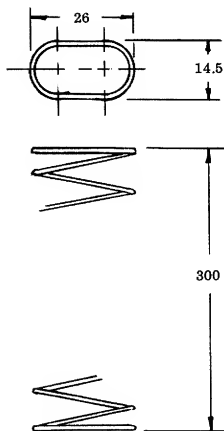


Magazine spring

Material: 1.3 ϕ music wire

Number of coils: 24

Overall length: 300mm



U.S. STANDARD/METRIC CONVERSION CHART

Millimeters to Inches
(Based on 1 inch = 25.4 millimeters, exactly)

Milli- meters	0	1	2	3	4	5	6	7	8	9
	Inches									
0	...	0.03937	0.07874	0.11811	0.15748	0.19685	0.23622	0.27559	0.31496	0.35433
10	0.39370	0.43307	0.47244	0.51181	0.55118	0.59055	0.62992	0.66929	0.70866	0.74803
20	0.78740	0.82677	0.86614	0.90551	0.94488	0.98425	1.02362	1.06299	1.10236	1.14173
30	1.18110	1.22047	1.25984	1.29921	1.33858	1.37795	1.41732	1.45669	1.49606	1.53543
40	1.57480	1.61417	1.65354	1.69291	1.73228	1.77165	1.81102	1.85039	1.88976	1.92913
50	1.96850	2.00787	2.04724	2.08661	2.12598	2.16535	2.20472	2.24409	2.28346	2.32283
60	2.36220	2.40157	2.44094	2.48031	2.51968	2.55905	2.59842	2.63779	2.67717	2.71654
70	2.75591	2.79528	2.83465	2.87402	2.91339	2.95276	2.99213	3.03150	3.07087	3.11024
80	3.14961	3.18898	3.22835	3.26772	3.30709	3.34646	3.38583	3.42520	3.46457	3.50394
90	3.54331	3.58268	3.62205	3.66142	3.70079	3.74016	3.77953	3.81890	3.85827	3.89764
100	3.93701	3.97638	4.01575	4.05512	4.09449	4.13386	4.17323	4.21260	4.25197	4.29134
110	4.33071	4.37008	4.40945	4.44882	4.48819	4.52756	4.56693	4.60630	4.64567	4.68504
120	4.72441	4.76378	4.80315	4.84252	4.88189	4.92126	4.96063	5.00000	5.03937	5.07874
130	5.11811	5.15748	5.19685	5.23622	5.27559	5.31496	5.35433	5.39370	5.43307	5.47244
140	5.51181	5.55118	5.59055	5.62992	5.66929	5.70866	5.74803	5.78740	5.82677	5.86614
150	5.90551	5.94488	5.98425	6.02362	6.06299	6.10236	6.14173	6.18110	6.22047	6.25984
160	6.29921	6.33858	6.37795	6.41732	6.45669	6.49606	6.53543	6.57480	6.61417	6.65354
170	6.69291	6.73228	6.77165	6.81102	6.85039	6.88976	6.92913	6.96850	7.00787	7.04724
180	7.08601	7.12538	7.16475	7.20412	7.24349	7.28286	7.32223	7.36160	7.40097	7.44034
190	7.48031	7.51969	7.55906	7.59843	7.63780	7.67717	7.71654	7.75591	7.79528	7.83465
200	7.87402	7.91339	7.95276	7.99213	8.03150	8.07087	8.11024	8.14961	8.18898	8.22835
210	8.26772	8.30709	8.34646	8.38583	8.42520	8.46457	8.50394	8.54331	8.58268	8.62205
220	8.66142	8.70079	8.74016	8.77953	8.81890	8.85827	8.89764	8.93701	8.97638	9.01575
230	9.05512	9.09449	9.13386	9.17323	9.21260	9.25197	9.29134	9.33071	9.37008	9.40945
240	9.44882	9.48819	9.52756	9.56693	9.60630	9.64567	9.68504	9.72441	9.76378	9.80315
250	9.84252	9.88189	9.92126	9.96063	10.00000	10.03937	10.07874	10.11811	10.15748	10.19685
260	10.23622	10.27559	10.31496	10.35433	10.39370	10.43307	10.47244	10.51181	10.55118	10.59055
270	10.62992	10.66929	10.70866	10.74803	10.78740	10.82677	10.86614	10.90551	10.94488	10.98425
280	11.02362	11.06299	11.10236	11.14173	11.18110	11.22047	11.25984	11.29921	11.33858	11.37795
290	11.41732	11.45669	11.49606	11.53543	11.57480	11.61417	11.65354	11.69291	11.73228	11.77165
300	11.81102	11.85039	11.88976	11.92913	11.96850	12.00787	12.04724	12.08661	12.12600	12.16537
310	12.20472	12.24409	12.28346	12.32283	12.36220	12.40157	12.44094	12.48031	12.51968	12.55905
320	12.59842	12.63779	12.67717	12.71654	12.75591	12.79528	12.83465	12.87402	12.91339	12.95276
330	12.99213	13.03150	13.07087	13.11024	13.14961	13.18900	13.22837	13.26774	13.30711	13.34648
340	13.38585	13.42522	13.46459	13.50396	13.54333	13.58270	13.62207	13.66144	13.70081	13.74018
350	13.77955	13.81892	13.85829	13.89766	13.93703	13.97640	14.01577	14.05514	14.09451	14.13388
360	14.17325	14.21262	14.25200	14.29137	14.33074	14.37011	14.40948	14.44885	14.48822	14.52759
370	14.56696	14.60633	14.64570	14.68507	14.72444	14.76381	14.80318	14.84255	14.88192	14.92129
380	14.96066	15.00003	15.03940	15.07877	15.11814	15.15751	15.19688	15.23625	15.27562	15.31499
390	15.35436	15.39373	15.43310	15.47247	15.51184	15.55121	15.59058	15.62995	15.66932	15.70869
400	15.74805	15.78742	15.82679	15.86616	15.90553	15.94490	15.98427	16.02364	16.06301	16.10238
410	16.14175	16.18112	16.22049	16.25986	16.29923	16.33860	16.37797	16.41734	16.45671	16.49608
420	16.53546	16.57483	16.61420	16.65357	16.69294	16.73231	16.77168	16.81105	16.85042	16.88979
430	16.92916	16.96853	17.00790	17.04727	17.08664	17.12601	17.16538	17.20475	17.24412	17.28349
440	17.32286	17.36223	17.40160	17.44097	17.48034	17.51971	17.55908	17.59845	17.63782	17.67719
450	17.71656	17.75593	17.79530	17.83467	17.87404	17.91341	17.95278	17.99215	18.03152	18.07089
460	18.11026	18.14963	18.18900	18.22837	18.26774	18.30711	18.34648	18.38585	18.42522	18.46459
470	18.50339	18.54276	18.58213	18.62150	18.66087	18.70024	18.73961	18.77898	18.81835	18.85772
480	18.89709	18.93646	18.97583	19.01520	19.05457	19.09394	19.13331	19.17268	19.21205	19.25142
490	19.29113	19.33050	19.36987	19.40924	19.44861	19.48798	19.52735	19.56672	19.60609	19.64546

Fractional measurements: to convert metric fractional dimensions to inches, multiply the metric dimension X .03937008

Weights: 1 kilogram = 2.2046 lbs or 35.274 oz.
1 gram = .03527 oz.
1 gram = 15.432 grains

•—Notes—•

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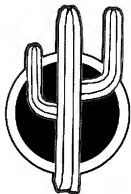
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